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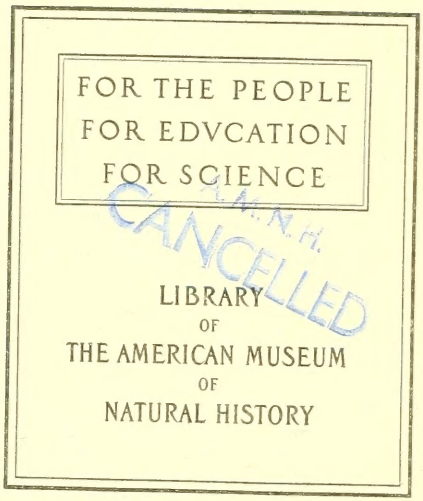

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BULLETIN No. 601

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THE HANDLING AND PRECOOLING OF FLORIDA LETTUCE AND CELERY.

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PREVENTING DECAY IN LETTUCE AND CELERY.

The lettuce and celery crops of Florida contribute annually about one and one-half million dollars to the incomes of the truck growers in that State. About 4,000 acres now are devoted to the culture of these crops, and this area is being increased constantly. The expansion of the celery industry has been especially rapid. Starting practically within the last decade, Florida is now one of the leading celery-producing States of the Union. The census of 1909 shows that Florida had then only 825 acres of celery. By 1913 the plantings had increased to 1,280 acres,[1] an increase of 55 per cent in four years.

The diseases and insect enemies to which most cultivated plants are susceptible quickly appear in new localities where the plants are introduced. Though they may not be apparent at first, when climatic and other conditions are favorable these enemies may so

[1] Agricultural statistics for the years 1913–14. *In* 13th Bien. Rpt. Dept. Agr. Fla., Div. Agr. and Immigr., 1913–14, p. 276. [1915.]

increase from year to year that the crops can not be grown successfully. Oftentimes the problems that have confronted the lettuce and celery growers during the past few years have been due to such conditions. Heavy losses have resulted from decay not only in the field, but in apparently sound produce while in transit. This condition made it seem desirable to undertake a series of investigations with a view to determining whether some practical commercial method could be devised for reducing the losses that occur from the time the products leave the field until they reach the consumer. The Bureau of Plant Industry has conducted handling and precooling investigations with several crops in other sections of the country, and similar investigations were begun with lettuce and celery in Florida in the autumn of 1913. During the season of 1913–14 particular attention was paid to the lettuce crop, and therefore this will be discussed first.

LETTUCE-HANDLING INVESTIGATIONS.

NATURE OF THE PROBLEM.

The experimental work was done in the vicinity of Palmetto, in Manatee County, the center of one of the largest lettuce-producing sections of Florida. Lettuce has been grown there on a commercial scale for 15 years or more. In a great many cases it was found that lettuce had been grown year after year on the same land. As a result, practically all the cultivated fields in this section are infected with disease-producing organisms.

Probably the most dangerous enemy of the lettuce crop is a fungus disease (*Sclerotinia libertiana*),[1] commonly known as lettuce drop, which causes tremendous losses yearly. Under conditions favorable to the growth of the fungus, whole fields sometimes are destroyed within a short period of time. The first indication of the presence of the disease is a slightly wilted appearance of the lower leaves. The drop produces a discolored or watery area on the under sides of the infected leaves, and this is followed quickly by the appearance of white threadlike masses. The disease spreads rapidly throughout the head, causing it to collapse into a slimy mass. Infected leaves often may be found on heads that appear to be perfectly healthy, and sometimes it is impossible to find in a field a single plant that does not show some signs of infection. Figure 1 shows a field in which practically all the plants are affected with the drop. The wilted appearance of these plants as compared with those in the disease-free field shown in figure 2 is very marked.

The general practice of most growers in preparing the lettuce for market is to cut off all plants close to the ground. The worst of the

[1] Burger, O. F. Lettuce drop. Fla. Agr. Exp. Sta. Bul. 116, p. 27–32, 3 fig. [1913.]

bottom leaves are then trimmed off, and the head is placed in the hamper or crate. The sole purpose of the trimming is to improve the appearance of the head, and often little or no attention is given to the presence of signs of disease. The hampers are packed tightly, the lettuce heads forming a compact mass that cools rather slowly. In addition, the hampers are loaded in the cars in such a manner as greatly to interfere with the natural air circulation. Figure 3 illustrates the usual arrangement of the load. The hampers are placed horizontally, with the tops and bottoms alternating. By this arrangement the hampers are fitted tightly together and the pressure is so distributed that they do not break readily. As usually loaded into

FIG. 1.—A lettuce field badly infested with the drop disease, from which no lettuce heads have been harvested.

the cars the hampers are four layers high. This leaves ample air space above the load, but the hampers are so close together that the circulation of air between them is very slow, and those in the center of the car retain the field heat for a long time. Most plant diseases develop rapidly at the higher temperatures, and this is particularly the case with lettuce drop. As a result, a great deal of lettuce has arrived on the market in unsound condition.

OUTLINE OF EXPERIMENTS IN 1913-14.

CAREFUL CUTTING.

In order to determine the effect of greater care in preparing lettuce for shipment, various methods of cutting were tested in these investigations. It seemed evident from the start that the infection occurred

mainly through the lower leaves, which rest on the ground. Therefore the lettuce was cut at a point just above these leaves. This method left the three or four under leaves untouched on the ground. If one or two of the leaves on the head showed signs of decay they were pulled off. If a large number of leaves were diseased or if the main stalk showed signs of disease, the head was discarded. Only lettuce that appeared entirely free from disease was included in these carefully cut lots. Figure 4 is a fair representation of the appearance of the lettuce when cut by either method. The commercially cut lettuce is dirty and shows diseased areas on the lower leaves,

FIG. 2.—A field of healthy lettuce, showing the condition of the plants at harvest time.

whereas that carefully cut is clean, attractive, and free from disease. The carefully cut lettuce was packed in accordance with commercial methods, and a similar lot, cut and handled throughout commercially, was obtained from the same field at the same time for purposes of comparison.

PRECOOLING.

The lots obtained each day were divided into two parts: Half of the carefully cut lettuce and half of that commercially cut were precooled, and comparable lots were placed under regular refrigeration.

The precooling was done by means of the portable precooling plant of the Office of Horticultural and Pomological Investigations. This

plant consists of a complete 12-ton refrigerating outfit installed in a freight car. Ammonia expansion coils in a well-insulated compartment at one end of the car furnished as low a temperature as was desired, and a 45-inch fan forced the necessary circulation of air. Refrigerator cars were loaded with lettuce in the usual manner and brought to the precooling plant, where cold air was then blown through the car, entering at one of the bunkers and going out at the other. Twelve electrical thermometers were distributed through the load. One thermometer was placed in the lettuce near the outside of the head end of the package and one in the center in each of six

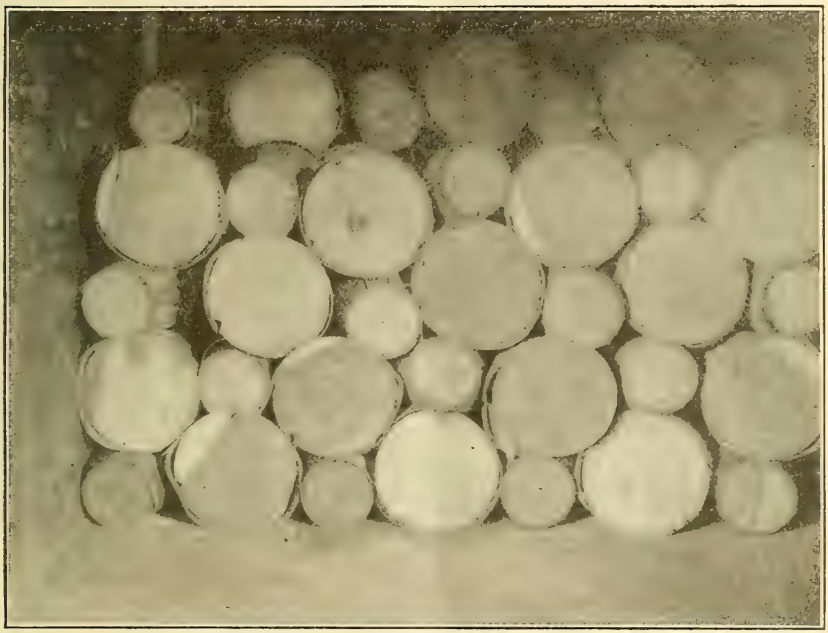

FIG. 3.—Hampers of lettuce loaded in a refrigerator car with very little space between the hampers for circulation of air.

hampers, which were located as follows: Two hampers at each end of the car, next to the bunkers, placed midway between the side walls, one at the top and one at the bottom of the load. The other two hampers were located as near the center of the car as possible, one at the top and one at the bottom of the load. The thermometers were connected with a main cable, which extended through the side ventilators to the outside of the car and provided a means of accurately determining the temperature at any time without opening the doors. The precooling was commenced as soon as possible after the cars were loaded and continued until the average temperature of all

the thermometers was about 40° F. It has been determined that this point is about as low as the ice in the bunkers will hold the load.

TREATMENT OF EXPERIMENTAL LOTS.

As has been stated, the precooled car contained an experimental lot consisting of an equal number of hampers of lettuce carefully cut and commercially cut from the same field at the same time. An exactly similar lot was shipped at the same time in a refrigerator car that was not precooled. The two cars went to the same market, in most cases to New York City, where a representative of the Department of Agriculture inspected them upon their arrival and again three days later.

Comparable lots, both precooled and nonprecooled, were held at Palmetto in an iced refrigerator car and kept under approximate

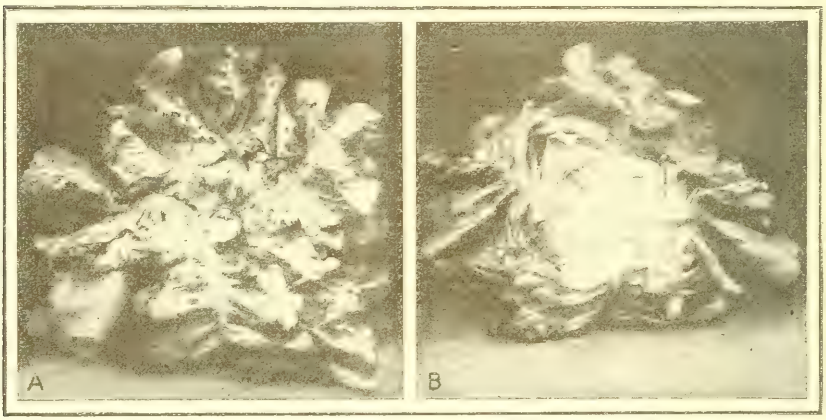

FIG. 4.—Two heads of lettuce, showing the difference in methods of cutting: *A*, Commercially cut *B*, carefully cut.

transit temperature conditions. It was possible to keep the temperatures in this holding car under close control, so that these lots give a good index of the effect of temperature on the development of decay. Six days after cutting—the average length of time required for the cars to reach the principal northern markets—the lettuce was removed from the holding car and inspected. It was then held at ordinary temperatures for three days and again inspected. Accurate records were kept as to the general condition of the lettuce and the amount of decay at each inspection.

RESULTS OF EXPERIMENTS IN 1913–14.

SHIPPING LOTS.

During the season of 1913–14 nine full comparable experimental lots were shipped to northern markets and 16 lots were held in Palmetto. The following tables and diagrams give a summary of

the results obtained as regards the general market condition and the amount of decay in lettuce treated in the different ways described.

The results of the inspections of experimental lots shipped to northern markets are shown in Table I.

The results recorded in Table I are represented graphically in figure 5. The open line in figure 5 represents the percentage of prime or first-class lettuce, the shaded line the percentage of marketable lettuce, and the solid line the percentage of worthless lettuce. The most striking point brought out by this diagram is the effect of careful cutting on the market condition of the lettuce. In the non-

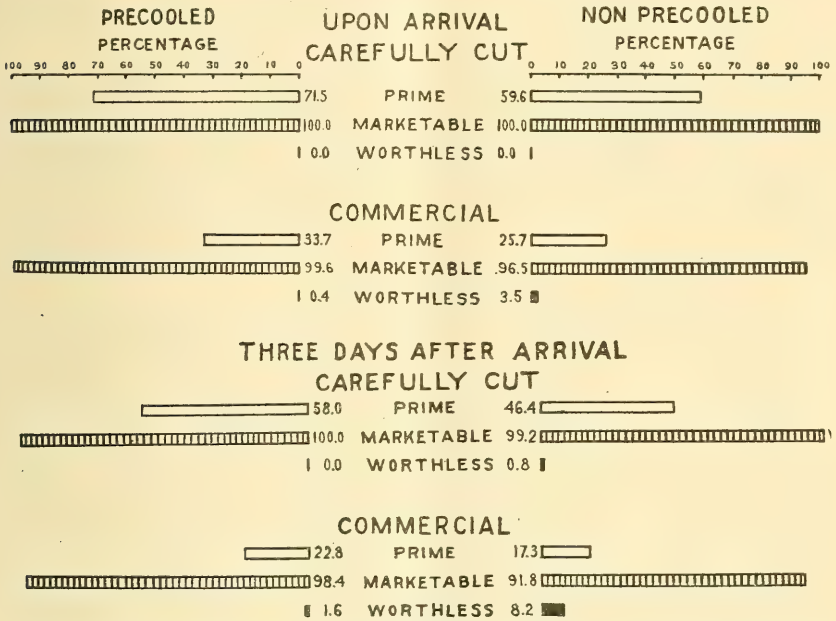

FIG. 5.—Diagram illustrating the percentages of prime, marketable, and worthless lettuce upon arrival at the market and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce shipped from Palmetto, Fla., season of 1913–14.

precooled series the carefully cut lettuce showed an average of 59.6 per cent in prime condition upon its arrival at the market, as compared with 25.7 per cent in the case of that commercially cut. The precooled series showed just as marked results: 71.5 per cent prime in the carefully cut, and only 33.7 per cent prime in the commercially cut lettuce. After holding for three days, the amount of first-class lettuce was considerably decreased, but in all cases the carefully cut lettuce showed over twice as much first-class lettuce as that commercially cut. The beneficial effects of precooling are well illustrated in this diagram, but are shown more strikingly in Table II.

TABLE I.—*Average market conditions of nine experimental lots of carefully cut and commercially cut lettuce shipped to northern markets during the season of 1913–14.*

Treatment.	At withdrawal.		Three days after withdrawal.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:				
Prime heads.....per cent..	59.6	25.7	46.4	17.3
Marketable[1] heads.....do....	100	96.5	99.2	91.8
Precooled:				
Prime heads.....do....	71.5	33.7	58	22.8
Marketable heads.....do....	100	99.6	100	98.4

[1] The term "marketable" as used here includes all heads with sound hearts, even though the outer leaves were in some cases more or less decayed.

Figure 6 shows the very striking results of careful cutting. Where the nonprecooled commercially handled lettuce on the first inspection shows a total decay of 44.5 per cent, the nonprecooled carefully cut lettuce shows only 8.8 per cent of decay, or, in other words, the method of cutting that keeps the infected lower leaves out of the

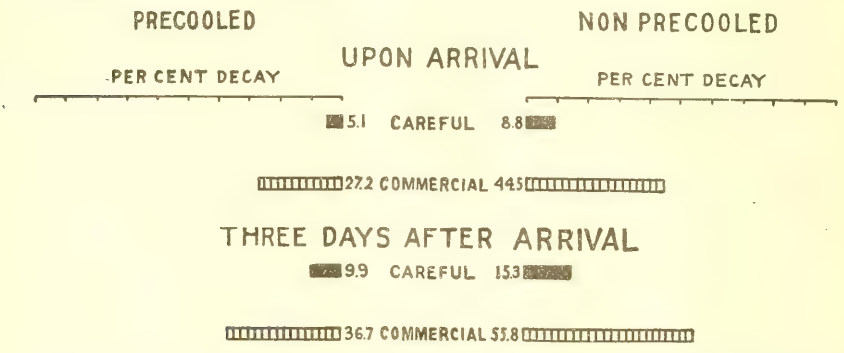

FIG. 6.—Diagram illustrating the percentages of drop decay found upon arrival at the market and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce shipped from Palmetto, Fla., in the season of 1913–14.

hamper reduces the decay four-fifths. A single glance at the diagram (fig. 6) shows the great difference between the carefully cut and commercially cut lettuce both upon arrival at the market and three days later, the short line in each case representing the decay in the carefully cut and the long line the decay in the commercially cut lots. The column on the left shows the average total decay in the precooled lots, and the column on the right the decay in the nonprecooled lots. Precooling had the greatest effect on the commercially cut lots. For example, the precooled commercially cut lettuce showed an average of 27.2 per cent decay upon arrival, in contrast to 44.5 per cent in the case of the nonprecooled. Precooling used in connection with careful cutting gives the best results, as the figures

indicate, i. e., a total decay of 5.1 per cent in the precooled carefully cut lot, as against 44.5 per cent in the nonprecooled commercially cut lettuce. As the latter is the common method of cutting and shipping lettuce, it is obvious that careful cutting and precooling eliminate a very large part of the decay that usually develops in transit.

TABLE II.—*Average percentages of decay in nine experimental lots of carefully cut and commercially cut lettuce shipped to northern markets during the season of 1913–14.*[1]

Treatment.	At withdrawal.		Three days after withdrawal.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:				
Heads showing slight drop rot ..... per cent..	7.9	24.2	11.7	30.3
Heads showing medium drop rot ..... do....	.9	16.9	3.3	19.6
Heads showing complete drop rot ..... do....	0	3.4	.3	5.9
Total drop rot ..... do....	8.8	44.5	15.3	55.8
Precooled:				
Heads showing slight drop rot ..... do....	4.7	20.6	8.5	26.8
Heads showing medium drop rot ..... do....	.4	6.3	1.4	8.3
Heads showing complete drop rot ..... do....	0	.3	0	1.6
Total drop rot ..... do....	5.1	27.2	9.9	36.7

[1] No record of bacterial decay was obtained in these lots.

In addition to the factors recorded above, the difference in appearance of the various lots was a point of great importance in determining their market value. Figure 7 shows the general appearance of the different lots at the first inspection. In almost every case the carefully cut lots were far more attractive, not only because less decayed but also because the heads were cleaner owing to the removal of the dirty lower leaves. The lettuce in the precooled hampers was also in much better condition than that in the nonprecooled hampers. Less shriveling, crisper, brighter leaves, and a general freshness of appearance, aside from any question of decay,

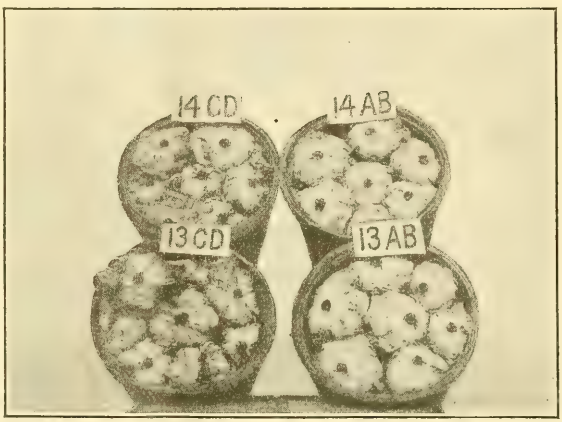

FIG. 7.—Appearance at the first inspection of lettuce handled in the following ways: Top hampers, marked "14," precooled; lower two, marked "13," not precooled; the hampers on the left, marked "CD," were commercially handled and the two on the right, marked "AB," were carefully cut.

usually made it easy to distinguish the precooled from the nonprecooled lots. The heads in the precooled hampers were usually level with the top of the hampers upon arrival at the market, while those in comparable nonprecooled hampers, because of shriveling and general decay, usually had sunk several inches below the top.

HOLDING LOTS.

The results of the inspection of sixteen experimental lots held in the refrigerator car at Palmetto are given in Tables III and IV and are shown in figures 8 and 9, respectively.

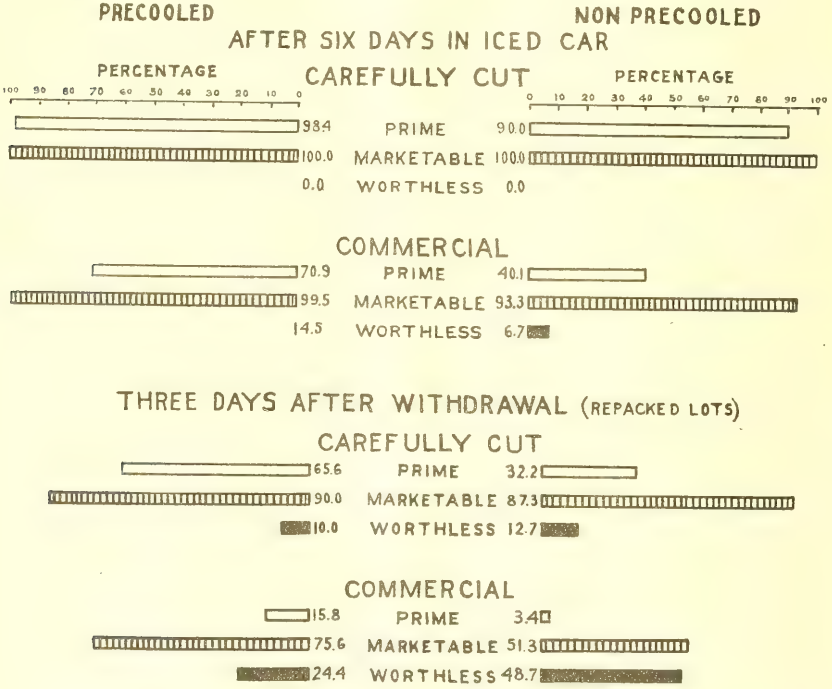

FIG. 8.—Diagram illustrating the percentages of prime, marketable, and worthless lettuce upon withdrawal from the car and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce held at Palmetto, Fla., season of 1913–14.

At the first inspection of the experimental lots held in Palmetto, one half of the lettuce in each basket was removed and inspected, the lower half being left undisturbed. The inspected half was then repacked and the whole basket held until three days later, when the two halves were inspected and recorded separately under the headings "Repacked" and "Undisturbed." This was done in order to learn what effect removal from the basket and handling while on the market had upon the lettuce. As is brought out in Table III, there is very little difference in the effect of the two methods, such difference as there is favoring the lettuce that was removed and repacked. Apparently moderate handling has little or no

harmful effect on lettuce, and, in fact the exclusion of air from the center of the packages may result in a more rapid deterioration than is the case when the heads are removed from the hampers and exposed to the air.

TABLE III.—*Average market condition of sixteen experimental lots of carefully cut and commercially cut lettuce held six days in an iced car at Palmetto, Fla., during the season of 1913–14.*

Treatment.	At withdrawal.		Three days after withdrawal.			
			Repacked.		Undisturbed.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:						
Prime heads.....per cent..	90	40.1	32.2	3.4	31.8	4.1
Marketable heads.....do....	100	93.3	87.3	51.3	81.5	49.5
Precooled:						
Prime heads.....do....	98.4	70.9	65.6	15.8	53.8	9.4
Marketable heads.....do....	100	99.5	90	75.6	94.3	63.4

The summary of the holding experiments shown in Table III is even more striking than the summary of the shipping lots shown in Table I. The effect on the carrying quality of the lettuce of the different methods of handling employed was relatively the same in

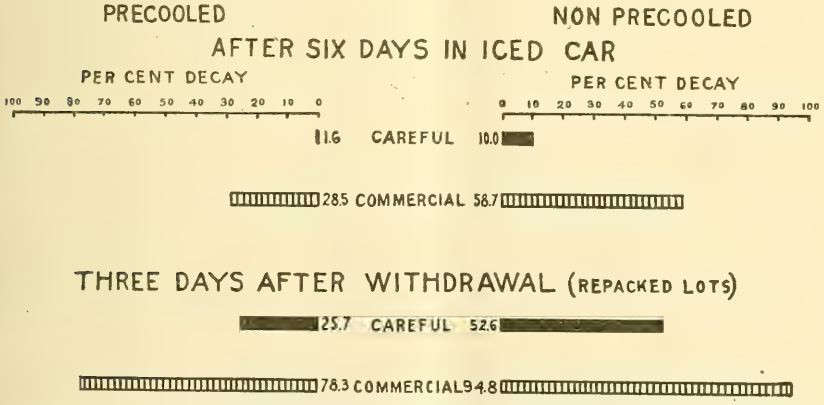

FIG. 9.—Diagram illustrating the percentages of drop decay upon withdrawal from the car and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce held at Palmetto, Fla., season of 1913–14.

both lots, but there was considerably more deterioration in the lots held at Palmetto, owing to the prevailing higher temperature. Here, again, the effect of careful cutting is shown most markedly. Over 98 per cent of the carefully cut precooled lettuce was in prime condition at the end of six days, as compared with less than 71 per cent in that commercially cut. In the nonprecooled lots the carefully cut lettuce showed an average of 90 per cent of prime heads

at the end of the 6-day holding period, while that commercially cut showed a little over 40 per cent—less than half as much.

The effect of precooling is shown best in the commercially cut lettuce. In the precooled lots practically all the lettuce was in marketable condition at the end of the 6-day holding period, and 70.9 per cent was prime, while the nonprecooled lots showed an average of 6.7 per cent of worthless lettuce and only 40.1 per cent prime. The high temperature at which the lettuce was held after its withdrawal from the refrigerator car caused it to decay very rapidly, as the lower part of figure 8 plainly indicates. The amount of worthless lettuce in the various lots three days after their withdrawal from the car is particularly worth noting. Contrasting one extreme of handling with the other, as shown in figure 8, the precooled carefully handled lettuce showed 10 per cent worthless and 65.6 per cent prime, whereas the nonprecooled commercially handled lettuce showed 48.7 per cent worthless and 3.4 per cent prime.

TABLE IV.—*Average percentages of decay in sixteen experimental lots of carefully cut and commercially cut lettuce held six days in an iced car at Palmetto, Fla., during the season of 1913–14.*

Treatment.	At withdrawal.		Three days after witddrawal.			
			Repacked.		Undisturbed.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:						
Heads showing slight drop-rot, per cent	8.6	36.2	27.1	25.6	22.9	19.8
Heads showing bad drop-rot, per cent	1.4	22.5	25.5	69.2	30	73.8
Total drop-rot [1] ....do..	10	58.7	52.6	94.8	52.9	93.6
Heads showing bacterial rot....do..	0	2.4	7.5	5.8	7.8	9.2
Precooled:						
Heads showing slight drop-rot, per cent	1.6	24	14.6	36.5	22.6	25
Heads showing bad drop-rot, per cent	0	4.5	11.1	41.8	13.7	57.3
Total drop-rot....do..	1.6	28.5	25.7	78.3	36.3	82.3
Heads showing bacterial rot....do..	0	.7	2.6	3.4	6.4	8.5

[1] In some cases both drop and bacterial decay were found on the same head. As these diseases were recorded separately, the total of all forms of decay may appear to amount to more than 100 per cent in some instances.

A glance at Table IV and the diagram shown in figure 9 gives a convincing impression of the effect of precooling and of careful cutting upon the development of decay. In the carefully cut nonprecooled lots only 10 per cent showed serious signs of drop-rot at the first inspection, at which time the comparable commercially handled lots showed 58.7 per cent. In the carefully cut precooled lots, the drop-rot was so slight as to be of almost no commercial importance, whereas in the commercially cut nonprecooled lots more

than half of the heads showed drop decay. Three days after withdrawal from the car the precooled carefully handled lettuce showed only 25.7 per cent of drop-rot, whereas the precooled commercially handled lots showed 78.3 per cent. The nonprecooled commercially handled lettuce showed an average of 94.8 per cent of drop decay or, in other words, at the final inspection of these lots practically every head was decayed more or less seriously.

COMPARISON OF HOLDING AND SHIPPING LOTS.

The differences in the amount of decay found in the experimental shipments of lettuce inspected at the northern markets and in corresponding lots held in Palmetto are shown in Table V.

TABLE V.—*Comparison of the total percentages of decay in precooled and nonprecooled lots of carefully cut and commercially cut lettuce shipped to northern markets and in comparable lots held at Palmetto, Fla., during the season of 1913–14.*

Treatment.	At withdrawal.		Three days after withdrawal.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut
Nonprecooled:				
7 holding lots.....per cent..	28.1	55.9	78.9	96.2
7 comparable shipments.....do....	20.1	39.9	30.6	53.2
Precooled:				
7 holding lots.....do....	2	9.6	22.2	50.6
7 comparable shipments.....do....	4.9	7.2	10.4	15.5

Table V shows that even at the first inspection the average decay was greater in the lettuce held in Florida than that in the lettuce shipped to northern markets, in spite of the fact that inspections at the North were made nearly two days later than those at Palmetto. At the second inspection the decay, as might be expected, was much greater in the lettuce held in Florida than in that held in the northern markets. This is undoubtedly accounted for by the difference in temperature between the two parts of the country during January and February, the months in which the experiments were carried on.

OUTLINE OF EXPERIMENTS IN 1914–15.

The experiments with lettuce, as outlined in 1913–14, were continued throughout the season of 1914–15. The weather conditions during this season were generally unfavorable, resulting in a poor quality of lettuce and very light shipments. The lettuce as a rule failed to make solid heads, and that shipped from the Palmetto section was chiefly of the leaf type. For this reason it was impossible to conduct the experiments on as large a scale as was desired. However, a number of cars were precooled, and experimental lots were again shipped to New York.

RESULTS OF EXPERIMENTS IN 1914–15.

The results obtained, which are summarized in Tables VI and VII, corroborated the results of the previous season's work recorded in Tables I and II.

TABLE VI.—*Average market condition of eighteen experimental lots of carefully cut and commercially cut lettuce shipped to New York City during the season of 1914–15.*

Treatment.	At withdrawal.		Three days after withdrawal.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:				
Prime heads.....per cent..	94	79.8	76.9	55.6
Marketable heads.....do....	99.5	98.8	95.6	87.2
Precooled:				
Prime heads.....do....	95.3	84.8	89	71.3
Marketable heads.....do....	99.6	99.2	99.7	97.3

The results shown in figure 10 are essentially the same as those obtained the previous year, but the figures are less striking, especially in the case of the precooling experiments. The weather conditions

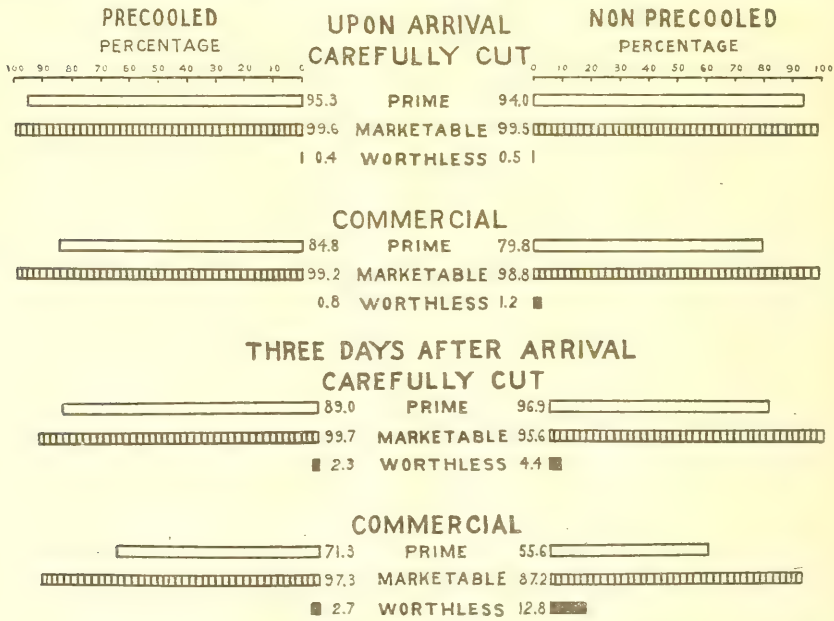

FIG. 10.—Diagram illustrating the percentages of prime, marketable, and worthless lettuce upon arrival at the market and three days later in precooled and in nonprecooled commercially cut and carefully cut lots shipped from Palmetto, Fla., season of 1914–15.

during the season were exceptional, and the temperature at the time of shipping was in most cases not high enough to render precooling imperative. In spite of this, it will be noted that all of the advantage is on the side of the precooled lettuce.

Table VII and figure 11 show the amount of decay found in the experimental lots of lettuce shipped during the season of 1914–15.

TABLE VII.—*Average percentages of decay in eighteen experimental lots of carefully cut and commercially cut lettuce shipped to New York City during the season of 1914–15.*

Treatment.	At withdrawal.		Three days after withdrawal.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:				
Heads showing slight drop-rot.....per cent..	4.9	15.6	17	27.4
Heads showing bad drop-rot.....do....	.4	2.8	5.9	14.8
Total drop-rot.....do....	5.3	18.4	22.9	42.2
Heads showing bacterial rot.....do....	.9	3.6	2.9	5.3
Precooled:				
Heads showing slight drop-rot.....do....	2.9	10.3	7.3	18.7
Heads showing bad drop-rot.....do....	1	2	2.6	7.9
Total drop-rot.....do....	3.9	12.3	9.9	26.6
Heads showing bacterial rot.....do....	1.4	3.5	1.9	4.4

Figure 11 shows graphically the amount of decay in the lettuce upon its arrival on the market and again three days later. In both

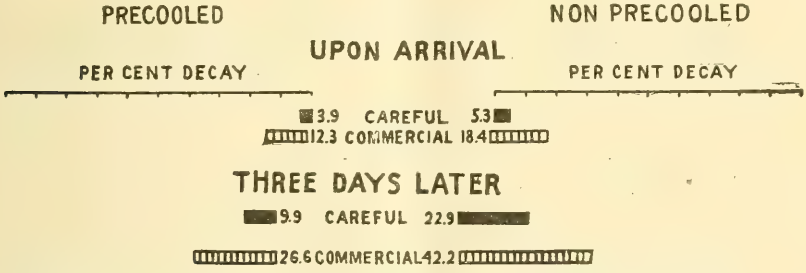

FIG. 11.—Diagram illustrating the percentages of drop decay upon arrival at the market and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce shipped from Palmetto, Fla., season of 1914–15.

precooled and nonprecooled lots the amount of decay in the carefully cut lettuce on arrival is less than one-third that in the commercially cut lots. Three days later the carefully cut precooled lettuce showed less than one-half as much decay as that commercially cut.

It is noticeable in Table VII that considerably more bacterial rot occurred in the commercially handled than in the carefully cut lettuce. From what is known of the nature of this disease it is not likely that this form of decay can be spread as readily by bad harvesting methods as the drop or that it will spread from head to head during transit or holding periods, as does the organism that causes drop. The smaller amount of bacterial rot shown in Table VII is probably due primarily to greater care in grading out diseased heads at the

time of harvesting. Only a slight difference is recorded between the amount of bacterial rot in the precooled and nonprecooled shipments made in 1914–15, although the holding lots shown in Table IV indicated considerably less bacterial rot in the precooled series for the season of 1913–14. Whenever bacterial rot was present it was found to increase greatly after the lettuce was withdrawn from the car and held at a warm temperature.

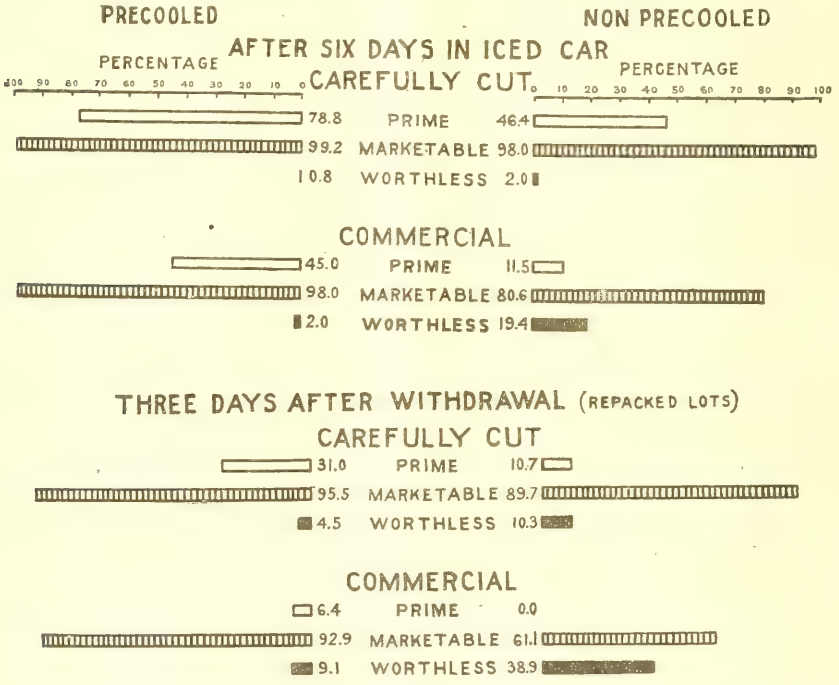

FIG. 12.—Diagram illustrating the percentages of prime, marketable, and worthless lettuce upon withdrawal from the car and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce held at Palmetto, Fla., season of 1914–15.

HOLDING LOTS.

In 1914–15 the holding lots were limited to seven complete series. Because of the shortness of the crop it was not always possible to secure enough carefully handled lettuce to provide for both holding and shipping lots. When this was the case, the holding lots were omitted.

Table VIII and figure 12 give a record of the market condition of the holding lots for 1914–15. A comparison of these results with those of the previous season, as shown in Table III and figure 8, gives a fairly good idea of the relative quality of the lettuce shipped during the two seasons. These two tables are comparable, because the lettuce in the holding lots was handled in the same manner during both seasons. The percentages of prime heads in all cases were greater in the 1913–14 lots. To some extent this may be due

to the fact that really first-class lettuce was very scarce in 1914–15 and that it was hard to classify small leafy heads as prime even though they showed no signs of decay. However, the inspections were made on as nearly the same basis as possible during both seasons. The percentages of marketable heads in the 1914–15 holding lots were fully as large, in general, as in the previous season. The effect of careful handling is clearly shown in Table VIII and figure 12. For the first inspection of the nonprecooled lots the average percentage of prime heads was 46.4 in the carefully handled lots and only 11.5 in the commercially handled lots, a fourfold difference in favor of careful handling. At the second inspection of the same lettuce

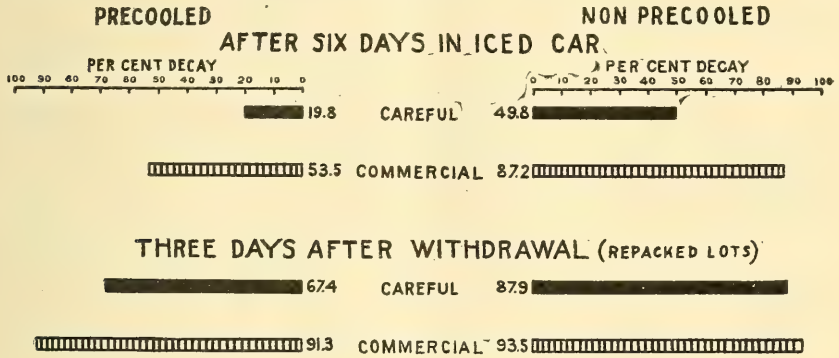

FIG. 13.—Diagram illustrating the percentages of drop decay upon withdrawal from the car and three days later in precooled and in nonprecooled commercially cut and carefully cut lettuce held at Palmetto, Fla., season of 1914–15.

made three days later, the carefully handled lots showed an average of 10.7 per cent of prime heads, whereas none of the commercially handled lots were of this grade. The effect of precooling is also very strikingly shown in these figures.

TABLE VIII.—*Average market condition of seven experimental lots of carefully cut and commercially cut lettuce held six days in an iced car at Palmetto, Fla., during the season of 1914–15.*

Treatment.	At withdrawal.		Three days after withdrawal.			
			Repacked.		Undisturbed.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:						
Prime heads.....per cent..	46.4	11.5	10.7	0	15.9	1.1
Marketable heads.....do....	98	80.6	89.7	61.1	84.4	56.9
Precooled:						
Prime heads.....do....	78.8	45	31	6.4	23.3	3.9
Marketable heads.....do....	99.2	98	95.5	92.9	96.2	85

Table IX and figure 13 show the percentages of decay found in the lettuce held at Palmetto during the season of 1914–15. It is inter-

esting to compare Table IX with Table IV, which records a considerably lower percentage of decay for the season of 1913–14. In some cases the average percentages of decay in 1914–15 were several times greater than in 1913–14. For example, the nonprecooled carefully handled lettuce showed only 1.4 per cent of heads with bad drop-rot in 1913–14, whereas the following year the comparable lot showed 12.3 per cent.

TABLE IX.—*Average percentages of decay in seven experimental lots of carefully cut and commercially cut lettuce held six days in an iced car at Palmetto, Fla., during the season of 1914–15.*

Treatment.	At withdrawal.		Three days after withdrawal.			
			Repacked.		Undisturbed.	
	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.	Carefully cut.	Commercially cut.
Nonprecooled:						
Heads showing slight drop-rot, per cent	37.5	45.2	47.6	22.2	40.3	19.4
Heads showing bad drop-rot, per cent	12.3	42	40.3	71.2	40.9	80
Total drop-rot [1] ....do....	49.8	87.2	87.9	93.4	81.2	99.4
Heads showing bacterial rot ....do....	.4	5.1	10.8	15.8	15	21.1
Precooled:						
Heads showing slight drop-rot ....do....	17.8	40.7	60 7	44.3	64.4	35.6
Heads showing bad drop-rot ....do....	2	12.8	6.7	47	8.3	45.2
Total drop-rot [1] ....do....	19.8	53.5	67.4	91.3	72.7	80.8
Heads showing bacterial rot ....do....	1.2	0	5.2	13.6	13.8	22.6

[1] In some cases both drop and bacterial decay were found on the same head. As these diseases were recorded separately the total of all forms of decay may appear to amount to more than 100 per cent in some instances.

In spite of the naturally inferior quality of the lettuce in 1914–15, the results of both the precooling and the handling work are very marked. The tables and diagrams will bear very close analysis, as they contain much more information than can be given in this brief discussion.

CELERY-HANDLING INVESTIGATIONS.

NATURE OF THE PROBLEM.

The celery-handling investigations were conducted at Manatee and Palmetto, Fla., mainly during the spring of 1915. At this season of the year high temperatures usually prevail in Florida and frequently occur throughout the North. When the celery is hauled from the fields to the car to be loaded, a temperature as high as 80° to 85° F. is by no means uncommon. The cars are loaded rapidly and the doors closed, confining all the heat within. It is manifestly impossible for the ice in the bunkers at either end of the car to reduce the heat to a safe temperature in as short a time as is desirable. As a matter of fact, the cooling that takes place in such a car is necessarily uneven

as well as slow. The crates generally are spaced an inch or two apart in order to facilitate the circulation of air, but even greater spacing would be by no means sufficient to equalize the rate of cooling throughout the car. The heavier cold air settles in the lower part of the car, and the entire lower layer therefore cools off rather quickly, though not as rapidly in the center as near the ice bunkers in each end. The upper layers, especially the top tier, cool off more slowly. This fact is particularly noticeable in cars that have been closed for only a few hours after being loaded. When the doors in these cars are opened the air near the floor feels cold, but that near the ceiling is often unbearably hot. This heat sometimes causes serious damage. The leaves turn light yellow, and as this injures the appearance of the celery and is recognized on the market as an indication of lessened vitality, crates containing celery with yellow tops are discounted accordingly. In general practice, when the car is unloaded the crates from the top of the load are purposely mixed with the more attractive crates of the lower tiers, in order to make them sell at a fair price. If the celery in the top crate is very yellow, however, the entire shipment is discounted 25 to 50 cents per crate below the price which it would have brought had there been no "yellow tops."

Celery from the Manatee section of Florida is shipped largely in crates 12 inches in depth. This is regarded as the standard crate in that section. In other localities, notably around Sanford, the 10-inch crate is the standard. The minimum freight rate is quoted on 350 crates regardless of size, and when the larger crate is used this number makes a load that reaches within 8 or 10 inches of the top of the car. Naturally, it is more difficult to lower the temperature in this car than in a car loaded with the 10-inch crates, where more space is left between the top of the crates and the roof of the car. In both cases, however, there is often serious damage due to slow cooling. In this connection, attention should be called to the desirability of the adoption by the growers of a standard-sized crate for all sections of the State.

OUTLINE OF CELERY-PRECOOLING EXPERIMENTS.

In order to determine the effect of precooling upon the temperature of the celery while in transit, two experimental cars were procured in March. Twelve electric thermometers were placed in various parts of the load in each car as in the case of the lettuce cars, and one of the cars was precooled. The bunkers of the precooled car then were topped off sufficiently to replace the ice that was lost by melting during the time it was being loaded and precooled, but no more ice was added during its entire trip. The other car was shipped in the usual manner, i. e., under full refrigeration. In

other words, this check car was topped off with ice after loading, and reiced in transit at the regular icing stations. A representative of the Department of Agriculture accompanied these cars and took accurate temperature records from time to time. The average temperature of the load in each car was computed from the 12 readings taken at each recording point.

TRANSIT TEMPERATURE RECORDS.

Figure 14 shows the average temperature of the celery in each car from the time it was loaded until it reached the market. The temperature of the outside air during the entire trip is shown also. The divisions at the left indicate degrees of temperature. The bottom divisions indicate the time in days. The small circles on each of the

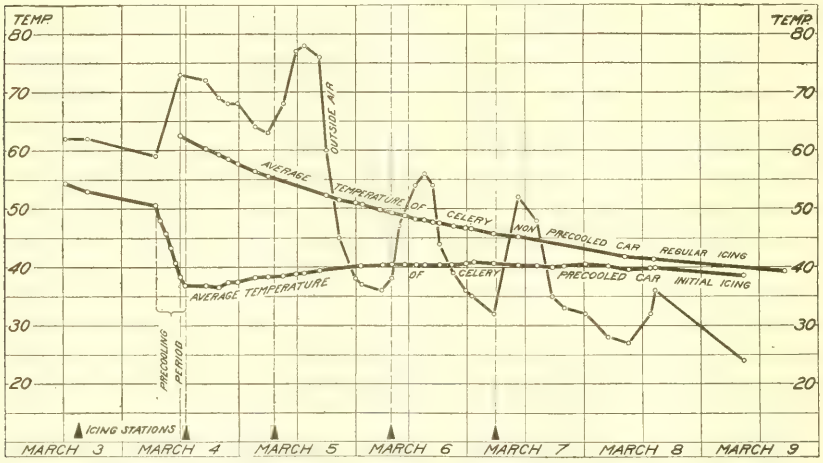

FIG. 14.—Diagram illustrating the average temperatures (° F.) of carloads of precooled and nonprecooled celery in transit from Florida to New York, season of 1915.

curves are placed at the intersection marking the time that the reading was made and the temperature at that time. The lower curve represents the temperature of the precooled car and the upper curve that of the nonprecooled car. The irregular curve running through the chart marks the outside air temperature.

The precooled car was loaded about noon on March 3, but was not cooled until the following morning, at which time the temperature of the car was only about 50° F. The first part of the curve illustrates this precooling period and shows the length of time required to precool the car and the temperature of the car at the time it was shipped. This point, about 37° F., was known to be lower than the ice would hold it, but as this was the first car shipped under initial icing it seemed desirable to be on the safe side by starting with a low temperature. The diagram shows very clearly how the temperature

crept slowly up to 41° F., and also how it remained at that point for almost two days in spite of large fluctuations in the outside temperature. It then began to drop below 40° F. again, owing to the cold outside temperature that the car encountered in the North.

The nonprecooled car was loaded on March 4 and started with a temperature of 62.5° F. It is interesting to note how very slowly the temperature of the celery in this car was lowered under the influence of ice alone. It was almost four days after leaving its starting point before it had reached as low a point as the precooled car maintained for the entire trip. It is during the first few days, as previously explained, that the damage by high temperatures is done. Subsequent cooling may prevent only further deterioration.

Figure 15 indicates the average temperature in the top and bottom tiers in both cars. It should be noted that during the entire trip the

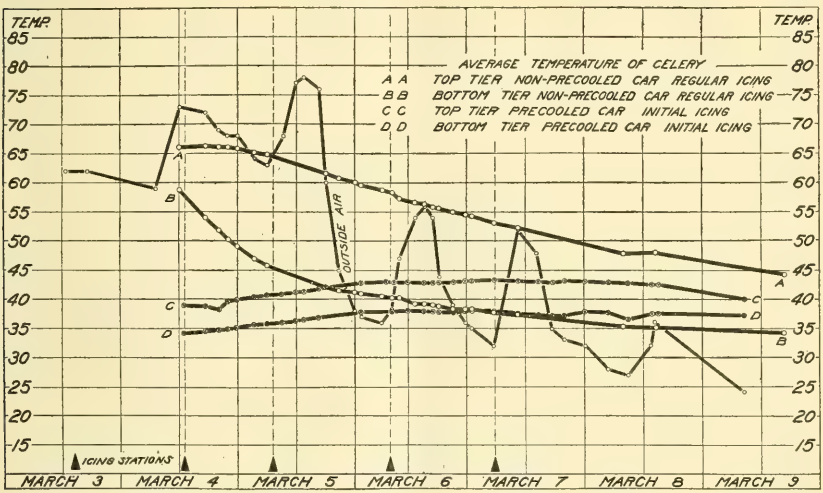

FIG. 15.—Diagram illustrating the average temperatures (° F.) of celery in the top and in the bottom layers of crates in carloads in transit from Florida to New York, season of 1915.

temperature of the top tier in the nonprecooled car was 10 degrees or more higher than the bottom tier. For a large part of the trip, the differences amounted to about 18 degrees. The precooled car, on the other hand, had only a difference of 5 or 6 degrees between the top and bottom tiers during the whole trip. The temperature in the bottom of the nonprecooled car went slightly below that of the precooled car after the third day, owing, no doubt, to the several reicings that it received in transit. The important point, however, is the fact that the temperature of the top tier in the nonprecooled car was far above that of the precooled car for the entire trip and even upon its arrival at its destination was still 5 degrees higher than the top tier of the precooled car. This seems to indicate that even after

five days in transit the field heat had not been removed from the upper part of the fully refrigerated car to the extent that it was removed from the precooled car at the time it left its starting point.

Figure 16 shows the maximum and minimum temperatures in both cars. Each point is the average of two thermometers placed in the same crate. One was inserted in the center of the crate and the other in the mass of leaves at the top. The minimum temperatures were obtained on the bottom tier next to the ice bunkers and the maximum temperatures were obtained on the top tier.

The maximum temperature in the nonprecooled car started at about 66° F. and rose during the first 18 hours to about 70° F. It then dropped slowly to a final temperature of 48° F. During the early part of the trip the difference between the highest and the

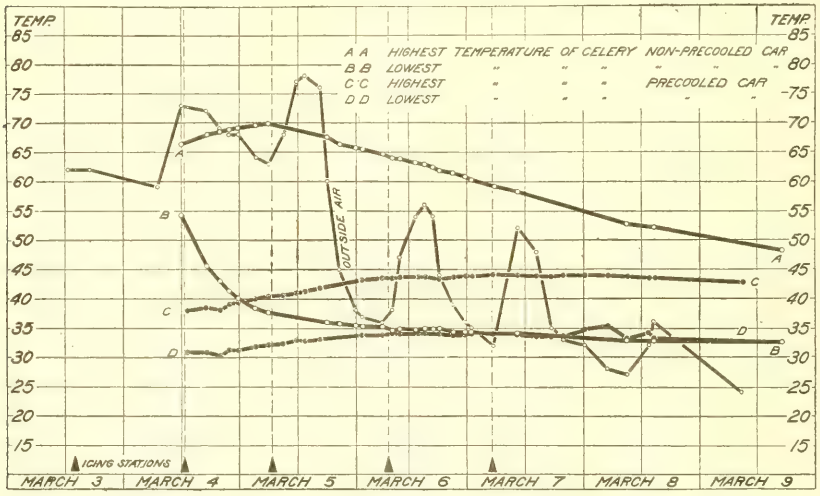

FIG. 16.—Diagram illustrating the highest and the lowest temperatures (° F.) of celery in carloads precooled and nonprecooled in transit from Florida to New York, season of 1915.

lowest temperature in the nonprecooled car was over 30 degrees, whereas in the precooled car the greatest difference was only about 10 degrees. If the precooled car had been iced in transit to make it comparable with the nonprecooled car, the difference in temperature between the top and bottom tiers would have been still less. As it was, the highest temperature in the precooled car was over 6 degrees lower than that of the nonprecooled car when it reached its destination.

The celery in the precooled car arrived on the market in fine condition. The leaves in the top crates were nearly as green as those in the bottom crates, and the receiver pronounced this car the best he had seen that season. The nonprecooled car arrived on the market showing the characteristic yellow leaves on the celery on the top tier.

COST OF PRECOOLING AND INITIAL ICING COMPARED WITH REGULAR ICING.

Attention must be called to the fact previously mentioned that the precooled car was handled under initial icing only. The charges on this car, aside from the regular transportation rate, were about $22 for ice, $7.50 special charge for the use of the car, ice tanks, etc., and $2 switching charges,[1] amounting to $31.50. In addition, the actual cost of precooling a car of celery is estimated at not more than $20.[2] This gives a total of $51.50 refrigeration charges on the precooled car. The full icing charge ordinarily paid amounts to $65. The experiment indicated, therefore, that by precooling and initial icing during the cooler weather not only better refrigeration could be obtained but also at a lower cost than by regular icing alone. The precooled car referred to arrived at its destination with the ice bunkers about one-third full. Two-thirds of the ice had melted, therefore, even during the comparatively cool weather in which it was shipped. Later shipments arrived on the market with very little ice remaining in the bunkers. To insure the best results in the warmest weather, it would seem advisable to reice the cars once while in transit.

OUTLINE OF CELERY-STORAGE EXPERIMENTS.

It was thought desirable to determine the effect of precooling not only upon the condition of the celery on its arrival at the market but also upon its storage qualities. Eight shipments therefore were made during the months of April and May, which mark the latter part of the celery-shipping season in Florida. Forty-eight experimental crates were included in each shipment. Half of these were in the precooled car and half in the nonprecooled car. Each lot was again divided, half being placed in the center of the car and half in the bunker end. Six crates from each of these lots were placed on the floor and six in the top layer. Thus the experimental crates in each shipment were exposed to the extremes of temperature in various parts of the car. All were shipped to New York City and upon arrival were placed in cold storage and held at a temperature of 32° F. An inspection of one-half of each shipment was made at the end of two weeks and of the remaining half at the end of four weeks.

STORAGE TROUBLES.

It was found that two serious diseases developed in the stored celery from Florida. These were designated as soft-rot and heart-rot. The soft-rot is somewhat similar in its development to the

[1] Precooling Tariff I. C. C. No. A3460.

[2] This estimate might be too low in the case of a small plant that is only run for a short time. In other cases probably it would be too high, as much depends upon the size of the precooling plant and the number of cars cooled.

lettuce drop and is said to be due to the same organism. Signs of it in storage are often first found on the leaves. It causes a soft, slimy decay that may consume the leaves entirely before seriously injuring the celery stalks. The disease causes the stalks to become discolored and watery and renders them unfit for consumption. Forms of this disease are encountered frequently in the field. The common foot-rot is said to be due to the same or a closely related organism.

Heart-rot is a term used to describe the darkening of the leaves and stalks forming the central bud or heart of the plant. This part first turns brown and later black, as the trouble develops. Heart-rot is found very often in the celery fields, especially late in the season. It appears to originate in the field, although some plants may have merely a predisposition to the disease at the time

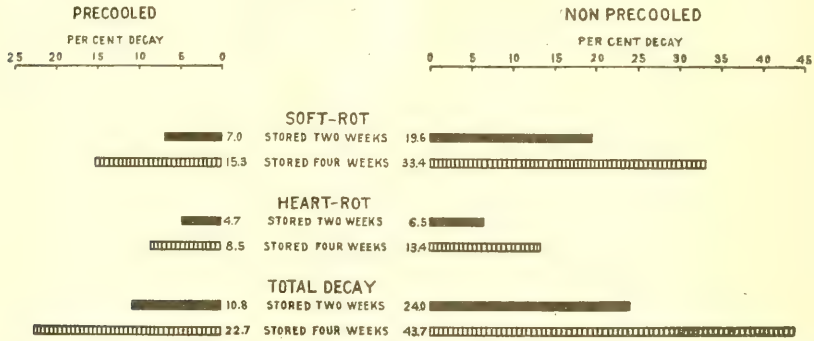

FIG. 17.—Diagram illustrating the percentages of soft-rot, heart-rot, and total decay at the end of two weeks and at the end of four weeks in storage at 32° F. in both precooled and nonprecooled celery shipped from Manatee, Fla., to New York, season of 1915.

they are cut and show no signs of it. It does not appear to spread to adjoining bunches in storage, but its development seems to bear some relation to the temperature to which it is exposed.

Leaf-spot also is a serious trouble, especially if celery is affected before being harvested. It frequently develops to an injurious extent in storage and is sometimes the cause of serious losses. Every effort should be made to control the leaf-spot and other diseases in the field through proper spraying and cultural practices. Celery entering storage in a diseased condition can not be held satisfactorily, even under the most favorable temperature and storage conditions.

RESULTS OF STORAGE EXPERIMENTS.

Summaries of the average results of the inspection of all the experimental lots of celery are given in the following tables and diagrams.

Table X and figure 17 show a comparison of the decay in the precooled and nonprecooled celery. The principal point brought out

by the diagram is the much smaller amount of soft-rot in the precooled than in the nonprecooled lot. In the celery stored for two weeks there was an average of 7 per cent of soft-rot in the precooled and 19.6 per cent in the nonprecooled, nearly three times as much in the latter case. At the end of four weeks the soft-rot in the precooled had more than doubled, but there was still twice as much in the nonprecooled celery. The amount of heart-rot also showed a consistent difference in favor of the precooled. The increase of

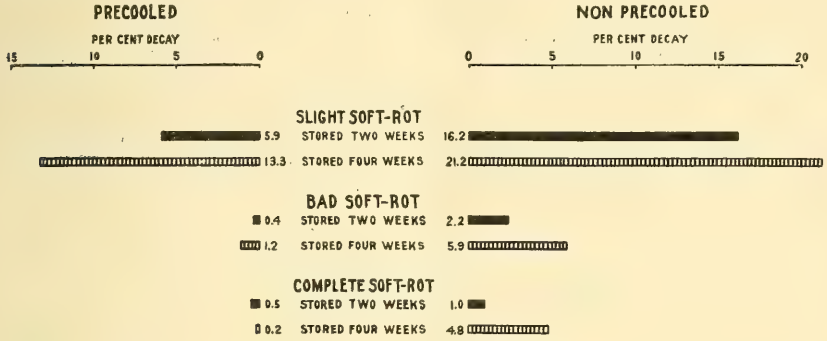

FIG. 18.—Diagram illustrating the percentages of slight, bad, and complete soft-rot at the end of two weeks and at the end of four weeks in storage at 32° F. in both precooled and nonprecooled celery shipped from Manatee, Fla., to New York, season of 1915.

heart-rot in the nonprecooled lots from 6.5 per cent at the end of two weeks to 13.4 per cent at the end of four weeks clearly shows that the trouble will develop in storage.

TABLE X.—*Average percentages of decay in storage of precooled and nonprecooled celery shipped from Florida, 1915.*

Disease.	Stored two weeks.		Stored four weeks.	
	Precooled.	Nonprecooled.	Precooled.	Nonprecooled.
Soft-rot.....per cent..	7	19.6	15.3	33.4
Heart-rot.....do....	4.7	6.5	8.5	13.4
Total decay [1].....do....	10.8	24	22.7	43.7

[1] In some cases both soft-rot and heart-rot were found in the same plant, but were recorded separately. Total decay refers to plants showing either or both forms.

Table XI and figure 18 show the various degrees of soft-rot at the different inspections. Celery was classified as having slight soft-rot if the decay was confined to not more than two or three stalks and bad soft-rot if the bunch showed considerable decay but still had a marketable "heart." "Complete soft-rot" was the term applied to the celery that was so badly decayed as to be rendered worthless. The diagram (fig. 18) shows that practically all the bad and complete soft-rot in the precooled celery was so slight as to

cause but little serious loss. The nonprecooled celery, on the other hand, showed considerable bad soft-rot and complete soft-rot. At the end of a 2-weeks' storage period the precooled showed less than one-half of 1 per cent of bad soft-rot in contrast to 2.2 per cent in the nonprecooled celery. Two weeks later there was still five times as much bad soft-rot in the nonprecooled as in the precooled. At the end of two weeks in storage the precooled celery showed 0.5 per cent and the nonprecooled 1.0 per cent of complete decay. At the last inspection the precooled celery showed 0.2 per cent and the nonprecooled 4.8 per cent, or at the end of the storage periods there was twenty times as much worthless celery in the nonprecooled as in the precooled lots. The slight inconsistency between the amount of complete decay at the end of two and four weeks is doubtless due to the comparatively small number of crates used in the experiment. The celery was discarded after the first inspection and a different lot of crates used in the final inspection.

TABLE XI.—*Percentages of slight, bad, and complete soft-rot in the storage of precooled and nonprecooled celery shipped from Florida, 1915.*

Disease.	Stored two weeks.		Stored four weeks.	
	Precooled.	Nonprecooled.	Precooled.	Nonprecooled.
Slight soft-rot.....per cent..	5.9	16.2	13.3	21.2
Bad soft-rot.....do....	.4	2.2	1.2	5.9
Complete soft-rot.....do....	.5	1	.2	4.8

The percentages in figure 18 clearly show the possibility of storing late Florida celery on the market from two to four weeks, especially if it has been precooled. Nonprecooled celery may reach the market in salable condition, but at this season of the year its storage is likely to be attended by serious loss, due to decay and to its decreased attractiveness. The practical applications of this may be found in storing celery at periods when prices are low or the market is temporarily overstocked. Celery then may be stored and held for a better price. A glance at the market reports will show how celery fluctuates at this season of the year, owing to weather conditions and the shipments from other sections. Toward the end of the shipping season, the storage of celery may help to bridge the interval between the close of the Florida shipping season and the opening of the season in the northern fields. However, this is done largely by shipments of celery from Bermuda.

Figure 19 shows the difference in the amount of decay that develops in celery carried on the floor of the car and that carried on the top tier. This is due, as previously suggested, to the much higher temperature in the top of the car. The difference applies to the pre-

cooled car as well as the nonprecooled, as the figures in Table XII prove, but it is much more marked in the nonprecooled car. In the precooled car, three times as much decay developed by the end of two weeks in the celery from the top tier as had developed in that from the bottom tier. In the nonprecooled car there was five times as much decay in the celery from the top tier as in that shipped on the floor. The decay in the celery shipped on the floor of the nonprecooled car was less than the average for the precooled car. This fact

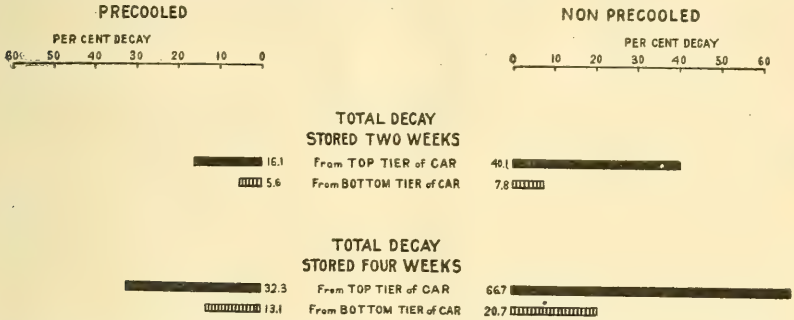

FIG. 19.—Diagram illustrating the percentages of decay at the end of two weeks and at the end of four weeks in storage at 32° F. in crates of celery from the top and from the bottom tiers in cars of both precooled and nonprecooled celery shipped from Manatee, Fla., to New York, season of 1915.

indicates that celery from the lower part of a nonprecooled car could be stored for this period with small loss. However, the upper tiers should be placed on the market as promptly as possible, to avoid excessive losses from decay.

TABLE XII.—*Percentages of decay in celery shipped in the top tier and the bottom tier in precooled and nonprecooled cars.*

Treatment.	Stored two weeks.		Stored four weeks.	
	Top tier.	Bottom tier.	Top tier.	Bottom tier.
Precooled.....per cent..	16.1	5.6	32.3	13.1
Nonprecooled.....do....	40.1	7.8	66.7	20.7

SUMMARY.

During the seasons of 1913–14 and 1914–15 investigations were conducted by the Bureau of Plant Industry for the purpose of ascertaining the causes of losses by decay in lettuce and celery shipped from Florida and to determine practicable means of reducing the same.

Decay in lettuce in transit was found to be due largely to lettuce drop, a disease which appears to enter the head mainly through the lower leaves.

Experimental heads of lettuce were cut just above the two or three lower leaves, and all diseased leaves were removed. This carefully cut lettuce developed far less decay in transit than the commercially cut lettuce.

Lettuce in cars that were precooled at the shipping point to a temperature of about 40° F. developed considerably less decay in transit than that shipped in nonprecooled cars.

The combination of careful cutting and precooling enabled the lettuce to reach its destination in almost perfect condition and to hold up much better on the market than lettuce handled in the usual manner.

Celery often is injured in transit because it is loaded too high in the cars to permit proper air circulation and rapid cooling. Smaller crates or a smaller number of crates in the load would help to insure more rapid cooling.

Temperature records taken in transit in a precooled, initially iced, and in a nonprecooled, fully iced celery car, showed that the nonprecooled took about four days to reach as low an average temperature as the precooled car maintained from the start.

During the entire trip from Florida to destination the temperature was never more than 5 or 6 degrees higher in the top tier than in the bottom tier of the precooled car, whereas in the nonprecooled car the difference amounted to 18 degrees for a considerable period.

The cost of precooling and initial icing of a car of celery was less than the usual charge for full refrigeration. In warm weather one icing in transit may be required, but probably this would not increase the cost above the usual full refrigeration charges.

Precooled celery arrived on the market in a uniformly fresh condition, with the leaves on the top tier nearly as green as those on the bottom. Nonprecooled celery showed very yellow leaves in the top tier. Such crates discount the value of the entire load.

During the latter part of the Florida celery-shipping season it appears that celery could be disposed of sometimes to better advantage if held in storage for a short period.

Precooled celery was stored successfully for four weeks with little decay, but stored nonprecooled celery developed considerable decay during the same period.

Celery from the lower part of a nonprecooled car can be stored for a short period, but during warm weather that on the top tier should be disposed of as soon as it reaches the market.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 602

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C. ▼ March 5, 1918

VALUE OF A SMALL PLOT OF GROUND TO THE LABORING MAN.

A STUDY OF THE FOOD RAISED BY OPERATIVES IN SOUTHERN COTTON-MILL TOWNS.

By W. C. FUNK, *Scientific Assistant.*

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Quantity and value of food raised by cotton-mill operatives	3	Pigs	8
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A large acreage of land in the United States can be used for agricultural purposes which is not generally classed as farm land. This area includes the numberless backyards and small holdings of less than 3 acres within and close by cities and villages. Much of this land already is being used for raising food for home consumption, but more is lying idle. The importance of utilizing this land is obvious. The family raising its food gets it at cost, which, as will be shown later, represents only actual cash expenditures.

Thousands of dollars worth of vegetables are raised in cities and villages at very small cost. The work is done by members of the consumer's family, with no cash expenditures except for seed and fertilizer. The last census reported over one million cows not on farms. Many of these are family cows kept by town dwellers to furnish milk and butter. With cheap pasture available a cow may be kept at a profit. The census reports over one million hogs not on farms, which indicates that much pork is produced by village and city families for home consumption. The number of poultry flocks not on farms is not reported, but probably more families keep chickens than keep cows or swine. These data show that the idea of utilizing small plots of ground for raising food is not a new one and emphasize the possibilities yet unrealized. (See pl. 1.)

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This bulletin sets forth results obtained from small plots of ground by over 500 families living in Southern cotton-mill villages. The facts and figures gathered in the study of the utilization of these plots for producing food are presented as suggestive of what the industrial establishment can do for the welfare of its employees by locating where the cost of living may be kept down by the home production of food. They may also serve to give the village or city dweller information as to the possibilities of raising food on small plots of suitable available ground.[1]

It refers particularly to the small plots of ground which may be used by village or city dwellers for raising vegetables, fruit, poultry, and even hogs and milk. The ground should be located conveniently so that the family may do most of the work. It is difficult to conceive of a laboring man's family using its spare time to better advantage than in cultivating the home garden or caring for a small flock of poultry or the family cow. The most productive garden or the most profitable flock of poultry, however, is the result of good management and intelligent care. If pride is taken in the garden and study devoted to its management, it will be a pleasure to plan for it during the winter and care for it during the summer. The man who finds recreation in fishing knows just what bait is best for each kind of fish; knows just where the best fishing places are, and the season when he is most likely to make a big catch. The successful home gardener or poultryman makes a study of this form of recreation with the same kind of enthusiasm that animates the keen fisherman.

The local retail prices used in this study were considerably lower than the prices current in large cities and towns at the time the study was made, and only one-third to one-fourth of the present prices (1917). The comparative cheapness of produce in these villages may be attributed to the fact that most families raise enough for their own use and a little over, so that in season the "store prices" of most vegetables or fruits are influenced greatly by the prices at which the consumer can buy them from a neighbor.

THE COTTON-MILL VILLAGE.

Southern textile companies furnish houses for the cotton-mill employees. The mill buildings, surrounded by the operatives' houses and the few necessary stores and shop buildings constitute the mill

[1] United States Department of Agriculture bulletins, State experiment station bulletins, and farm papers give information pertaining to garden culture, the amount of land needed for a small flock of poultry or a family cow, and the kinds of feed to use. A talk with a neighbor who has had success with his garden or his poultry is suggested. He may be able to give some good information. Good seed catalogues also give certain information on garden vegetables.

village. (See pl. II.) The operatives pay a nominal rent for the use of the dwellings, rarely exceeding $1 a month per room. The average size of house is three to four rooms per family. The houses are built on separate lots, which vary considerably in size in the different villages. One-fourth of an acre is a fair average size. This extra space on the house lot is intended especially for garden or poultry uses. This organization of an industrial community is peculiar to cotton-mill villages. In addition to the land around the houses provided for gardens the company often sets apart a pasture immediately adjoining the mill village for the free pasturage of the operatives' cows.

Some mill owners offer other inducements to the operatives. One company has a demonstration garden of half an acre. An expert is employed to grow a great variety of vegetables, showing the best cultural methods for each variety. The plot is intended as a model in planning a garden and creates much local interest in gardening. Another mill owner has a pure-bred dairy bull, whose services are free to the operatives owning cows.

In a number of villages interest in gardening is stimulated by offering prizes for the best gardens. The scoring is based on general appearances. This has the general effect of cleaning up the village and encourages the growing of flowers as well as vegetables. The front yard is beautified along with the back yard (see Pl. III). In no village visited, however, were prizes offered on the quantity of vegetables raised in the garden. This logically might be the next step. The family raising the most vegetables naturally will tend to keep the surroundings of the home in good order and at the same time to be better off financially.

QUANTITY AND VALUE OF FOOD RAISED BY COTTON-MILL OPERATIVES.

A large number of families were visited in nine different mill villages in the western parts of North Carolina and South Carolina to gain an idea of the economies of the vegetable garden, the small poultry flock, and the family cow under village conditions. The survey method was used in collecting the information. Effort was made to avoid the unusual and to study plots representing average conditions.

Records were taken of 548 gardens, 165 poultry flocks, 74 cows, and 62 hogs. It is felt that the number of records of each enterprise is sufficient to arrive at a fair average of actual conditions. Some of the families fed their stock at a loss and others had poor returns from their gardens. The data thus represent the result of poor management as well as of good.

The operatives are almost exclusively native people of the South. Many of them were formerly farmers in western North Carolina and South Carolina who were drawn to the mills by the steady occupation they offered to the whole family. Their farming experience naturally aids them in the village gardening and in the proper feeding and care of the live stock.

THE GARDEN.

The most important of the small enterprises conducted on the lots is the garden. It furnishes throughout the summer a great variety of food which can be gathered fresh each day. With proper care and planning, a garden of average size in the regions studied will

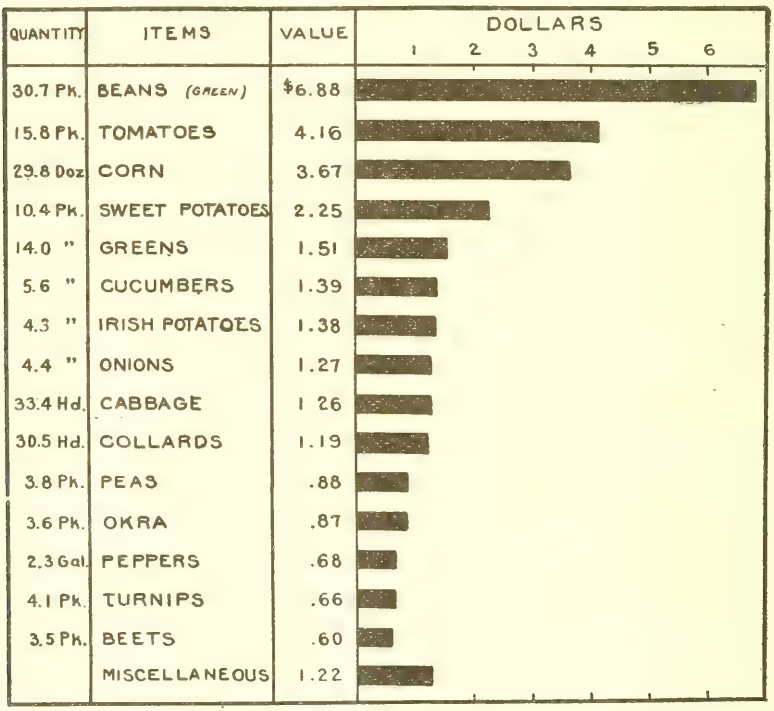


FIG. 1.—Comparison of the average value of vegetables raised on 548 gardens. The average size of these gardens is 723 square yards, or about one-seventh of an acre.

furnish fresh vegetables for six months during the year, and even longer if winter gardens are planted.

The average value of vegetables raised on the gardens visited was $29.87 (see fig. 1). This includes returns from some very poor gardens and some very good ones. In one of the villages, for instance, where a large number of families were visited, one-third of the gardens produced vegetables to the average value of $48, and

the other two-thirds produced on the average only $16 worth. The average good garden was only one-tenth larger in area and cost only one dollar more for labor, fertilizer, and seed than the average poor one.

SIZE OF GARDENS.

The average area devoted to gardens by all families visited is 723 square yards, or 0.15 of an acre. This area varies considerably, even in the same village, the size being dependent both on the area available and on the inclinations of the family. Some families do not begin their work in time to utilize all the land available, some care to raise only a few varieties of vegetables, and others think the returns are not worth the attention necessary. "We do not bother with much of a garden" is a common expression. A small poultry yard may take up a large part of the lot.

As would be expected, the value of vegetables raised is greater on the larger gardens, though the value of vegetables raised per square yard is less. The amount expended on the gardens and the variety of vegetables raised increase with the increase in area of garden.

The fact that the large gardens show the larger returns should not be taken to indicate that the small gardens all give low returns. It is found, for instance, that of the 144 families who have gardens of sizes between 300 and 499 square yards, 35 raise on an average nearly $50 worth of vegetables, which is considerably more than they pay for rent per year.

The value of vegetables sold is greater for the larger gardens, but at most the amount sold is comparatively small. The surplus vegetables raised generally find a ready market. It is a common practice in some villages for one to give to neighbors the small surplus raised or exchange it for other vegetables.

A very small quantity of the vegetables raised is canned for future use. It was found than on an average only 28 quarts were canned from the largest gardens, while the average number of quart cans of vegetables "put up" for all the families was but 22. The average number of those who canned was 37. A little more than one-third of the families did no canning. Beans and tomatoes often are raised in larger quantities than can be utilized for family purposes during the season and might be canned for use during the winter when fresh vegetables must be bought.

SIZE OF FAMILIES HAVING GARDENS.

The average number of persons per family, for all the families visited, in terms of adults, was 4.5,[1] boarders being included as members of the family. Arranging the records according to the size of the

[1] In giving the size of family in terms of adults, children 12 years of age and less are counted as one-half of an adult, and all persons older as adults.

family, it is found that the families of five persons and less averaged $26 worth of vegetables raised, and those of over five persons averaged $39 worth. The large families, however, have gardens one-third larger than the small families. The fact that only a small part of the vegetables raised are sold indicates that the vegetables are raised for home consumption. Thus the larger the family the greater the quantity of vegetables that must be raised. Hence it was found that the larger families either had larger gardens than the smaller families or cultivated their land more intensively.

VARIETY OF VEGETABLES GROWN.

Twenty-two kinds of vegetables were grown on these gardens, though no one garden was found which grew them all. An average of 9.5 kinds were grown per garden. The vegetables grown most commonly are those returning the most money, as shown in Plate I. Beans, tomatoes, and sweet corn are grown on nearly all the gardens. Peppers, cucumbers, beets, and greens[1] are grown on over three-fourths, and okra, onions, and peas on over half the gardens.

In one village a man with a garden 544 square yards in area planted 20 kinds of vegetables and raised $115 worth. In the same village another man had a garden of 650 square yards, planted 17 kinds, but raised only $21 worth. The former simply raised a much bigger crop per square yard than the other.

In order to see whether the variety of vegetables raised had any effect on the returns from the gardens, all the records of gardens, the sizes of which were over 500 square yards but less than 700, were classified by the number of kinds of vegetables grown. Those having 10 or more kinds were put in one group, and those having fewer in another group. The former group had on an average, for 71 gardens, averaging 577 square yards, 12 kinds of vegetables, the value of which was $33. In the other group were 64 gardens, averaging 591 square yards, raising 7 kinds to the value of $20. Thus the best gardens in this region grow more than 10 different vegetables. The best success on a limited area, however, involves careful planning, so as to have as much space as possible for each class of vegetables. The proper succession of vegetables must be known. Late vegetables may be planted between the rows of earlier vegetables, allowing the late crop to grow while the earlier ones are maturing. Thus successive crops may be obtained. Often three crops are taken from the same ground. Individual attention and knowledge of gardening are essential.

[1] Greens include mustard, lettuce, and turnip greens.

CASH EXPENDITURES ON GARDENS.

The average cash cost per garden was $3.54, distributed as follows:

Labor	$1.51
Seed	1.51
Fertilizer	.52
Total	3.54

This includes only the cash for hired labor, seed, and fertilizer. The labor expenditure is limited practically to the cost of having the garden plowed and harrowed for planting. Little or no labor is hired during the season, the planting and care of the garden being done by the family. The use of the land is not charged against the garden, as the rent paid for the use of the house includes the use of the lot, whether it is used for garden or other purposes. For gardens of the same size the returns are greatest where the expenditures are greatest. On these, however, the range of vegetables grown is also greater, indicating that those who spend more for labor, seed, and fertilizer also utilize their opportunities in other directions. The best gardeners have the seed-bed well prepared, purchase good seed, and apply fertilizer intelligently.

WINTER GARDENS.

Collards, a variety of kale, are grown in the fall and winter on about one-fourth of the gardens visited. This crop is mentioned here particularly because it does not compete with any other crop. In one village where 42 gardens grew collards and 45 did not the former averaged $9 worth of collards, and the average total value of vegetables raised was $34. The latter group grew no collards and the vegetables raised were valued at $24. The gardens were a little smaller in the first group. Families who relish this vegetable for greens will find it a profitable crop. Turnips, sown after the other vegetables are taken off, are often grown in the winter for greens.

FRUITS.

The average value of fruits raised for all the families visited was only $0.72, but the average for those who raised fruit was $3.20. Three-fourths of the families visited did not raise fruit of any kind. The fruit most commonly raised was the peach, with an occasional family having berries or apples. More fruit could be raised to advantage. The continual changing of tenants probably accounts for the small amount of fruit raised. Peaches, and even small fruit, must be set out a few years before returns are realized, and the tenant who has doubts of his remaining on his place for more than two years will not set out fruit for the benefit of some one else. The initiative

of the mill owners probably would be required to bring about the more general growing of peaches and small fruits in the villages.

POULTRY.

A large number of the families in these villages keep small flocks of poultry. Very little pure-bred stock was found, most of the flocks consisting of mixed breeds. The poultry houses were of a very temporary type, and inexpensive.

The average size of the 165 flocks from which records were taken was 13.2 fowls. The number of eggs used and sold averaged 86 dozen, valued at $19.35, and the number of fowls used and sold was 36, valued at $11.07, giving a total income of $30.42 per flock. The average expenditure for eggs, fowls, and wire bought was $1.16, and that for feed was $15.06, making a total expenditure of $16.22. The net return for these flocks thus was $14.20, or $1.08 per fowl. Labor cost and interest on investment in buildings and fowls are not charged against the flock. The labor was performed by the family, and the interest on the investment is negligible. The feed bought consists largely of cracked corn and other cereals. It is bought ready mixed, in peck and bushel lots. Table scraps are generally fed to the poultry, which reduces the feed bill. The value of the family table scraps is not included in the feed cost. Feeding to the poultry is a very economical way of disposing of the table wastes. Twelve flocks were fed wholly on table and garden wastes.

The flocks are penned the greater part of the year to keep them from running on the gardens. Thus, unlike the average farm flock, they are not able to find any of their feed.

The family in these villages which keeps a small flock of good fowls, feeds them carefully, and keeps them fenced in finds them profitable.

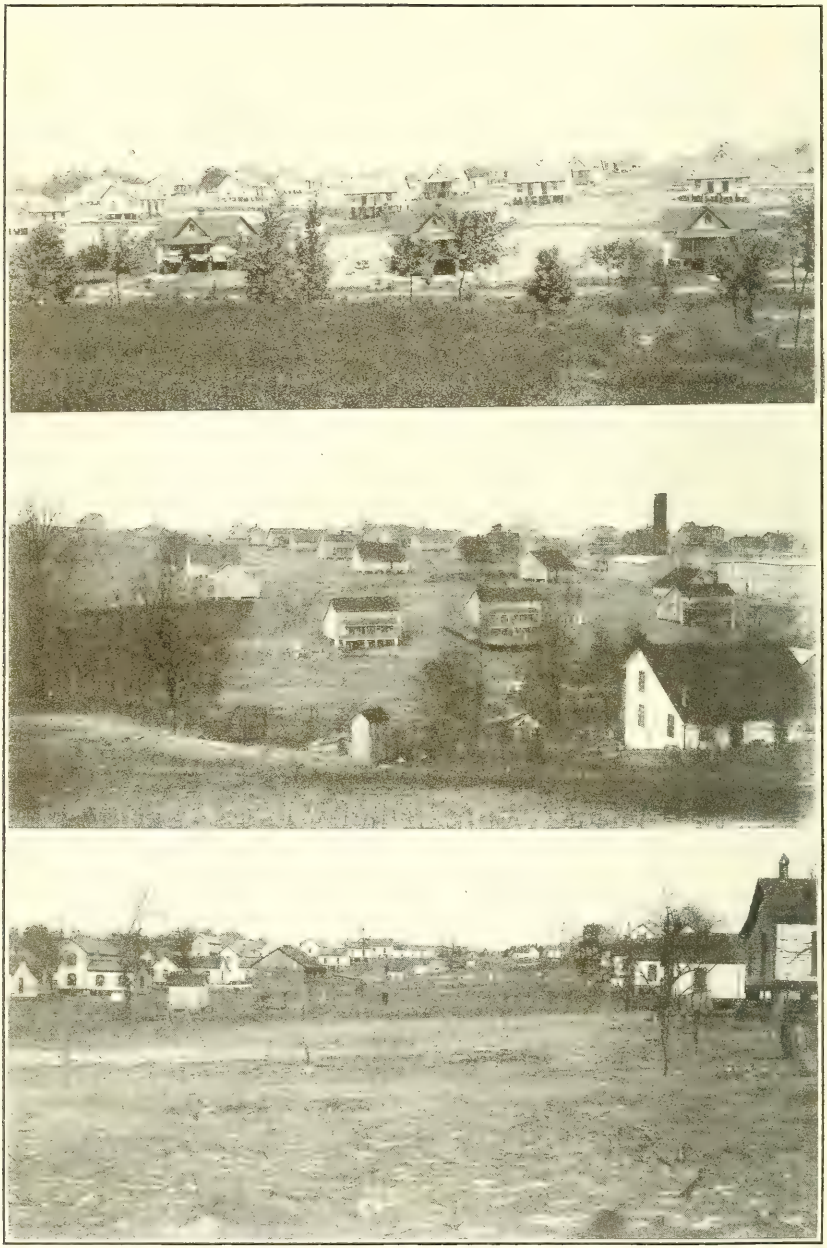
PIGS.

In most of the mill towns pigs are not allowed within the village proper for sanitary reasons. Some families have the pen located just outside the village and the necessity of carrying the feed a long distance is a discouraging factor.

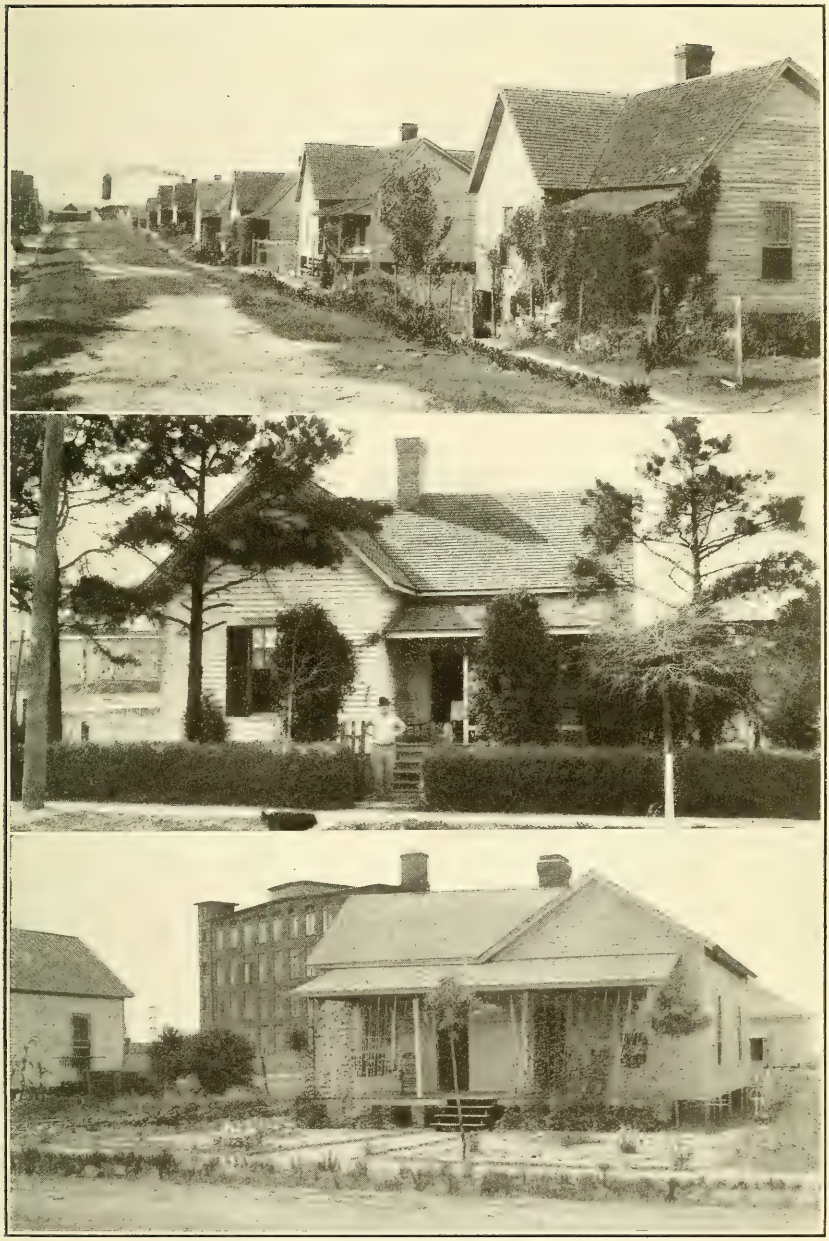
Records were taken of 62 hogs that had been fattened. The average purchase price of the pigs was $6.34, and the average live weight at killing time 270 pounds—worth $24.30 at $0.09 a pound. The cost of feed amounted to $12.12, leaving a net return of $5.84 after deducting the purchase price.

The feed bought consisted largely of shorts, corn, mill feed, kitchen scraps bought from neighbors, and a little buttermilk. The money

THE UTILIZED AND THE WASTED LOT CONTRASTED.



GENERAL VIEWS OF VILLAGES, SHOWING SPACE AVAILABLE FOR EACH FAMILY.



THE FRONT YARD IS BEAUTIFUL AS WELL AS THE BACK YARD.

paid for purchased kitchen scraps was $2.57 per hog. The value of the home kitchen wastes fed was not included in the feed cost. The feeding period extended over an average of ten months. These data indicate that it is profitable for the mill operative to fatten a pig when all feed does not have to be bought. Some of the families fatten only one hog and buy little feed, depending largely on their kitchen wastes. Other families fatten two or more pigs and rely more on materials bought for feed.

THE FAMILY COW.

In most of the cotton-mill villages the operative is encouraged to keep a family cow. Pastures adjoining the village proper are available for the free use of the families having cows. These pastures are fully utilized. In some instances the mill company has put up substantial stalls for housing the cows, and in other villages the operatives build cheap, temporary structures for this purpose.

The cows invariably are bought in the immediate neighborhood from farmers or neighbors. The quality of the cows is good. It is not uncommon for the operative to buy his cow on the basis of actual production at the beginning of the lactation period. The cow is bought as a "two, three, or four gallon" cow.

The practice in making butter in this regon is to churn the whole milk. The buttermilk, of which there is a quantity nearly equal to the quantity of whole milk produced, is used for drinking purposes. The large families use all the buttermilk produced, and the smaller families sell their surplus to neighbors. It commonly sells at 10 cents a gallon.

Records of the cost of feeding and of the value of buttermilk and butter produced were obtained from 74 cows. The data are given in the following table:

Record of 74 family cows owned by operatives in cotton-mill villages of the western parts of North Carolina and South Carolina.

[Value per cow, $46.]

Feed and yield per cow.	Quantity.	Value.
Feed:	*Pounds.*	
Roughage (pea-vine hay, alfalfa hay, corn stover)	1,000	$9.88
Cottonseed hulls	4,535	33.60
Cottonseed meal	1,700	32.04
Shorts	140	2.20
Mill feed	170	2.77
Total		80.49
Yield:		
Buttermilk.....gallons	605	60.50
Butter.....pounds	270	59.40
Total		119.90

The records are for the year 1915. The cows have the run of free, common pasture all summer, but the pastures are kept closely cropped.

The average value of the cows as estimated by the families was $46. The average cost of feed per cow was $80.49 a year. The average returns were $119.90. These comparatively high returns are attributable to the high value of the buttermilk, which is worth a little more than the butter. The butter alone would not pay for the feed.

It is evident that where the families in these villages do all the work, and the use of the pasture and stable is free, it may be more profitable for large families to have their own cow than to buy milk and butter for family use.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE RELATING TO THE SUBJECT OF THIS BULLETIN.

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Standard Varieties of Chickens. (Farmers' Bulletin 51.)
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Do You Keep a Cow? (Secretary's Special, 1914.)
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The Production and Care of Milk and Cream. (Secretary's Special, 1914.)
How Southern Farmers May Get a Start in Pig Raising. (Secretary's Special, 1914.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE.

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A Study in the Cost of Producing Milk on Four Dairy Farms, Located in Wisconsin, Michigan, Pennsylvania, and North Carolina. (Department Bulletin 501.) Price, 5 cents.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 603

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

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A STUDY OF SHARE-RENTED DAIRY FARMS IN GREEN COUNTY, WIS., AND KANE COUNTY, ILL.

By E. A. Boeger, *Agriculturist.*

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The great increase in American dairy farming and the spread of farm tenancy in dairy regions together tend to emphasize the need for exact knowledge concerning the relation between landlord and tenant on share-rented dairy farms. The work described in this bulletin was undertaken in two representative dairy regions with a view to ascertaining the nature of this relationship and determining the profits made thereunder by landlord and tenant.

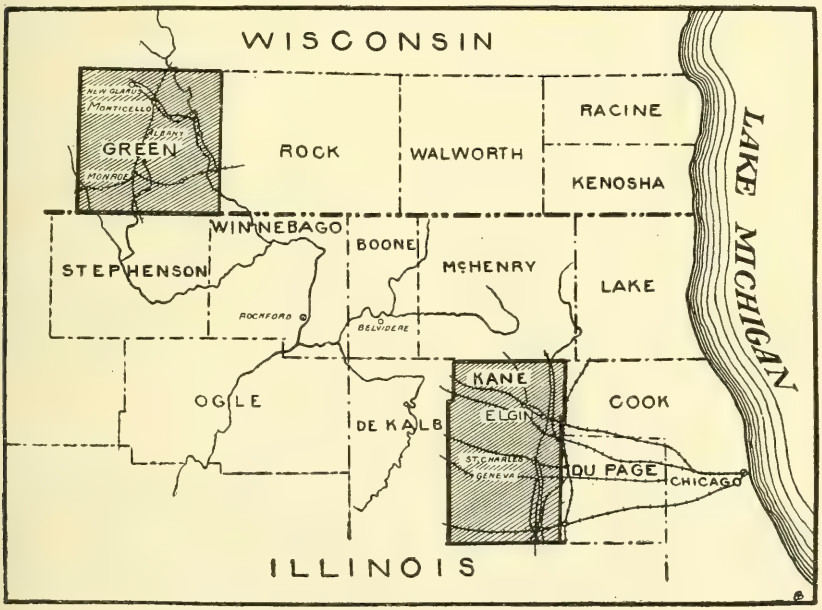

FIG. 1.—Location of areas in which records were taken.

Each of the regions selected for this study is a comparatively old dairy section. The one is in Green County, Wis., where dairying was first started for the manufacture of Swiss cheese, and the other about Elgin, Ill., where the first impetus to dairying was the establishment of butter factories (see fig. 1). In the former region, the supplying of milk to condenseries is now encroaching on the cheese industry, while in the latter region nearly all of the milk is either sold for condensation or to the Chicago market.

The material for this study was obtained from 84 farm management survey records taken in the Wisconsin region in cooperation with the State Agricultural College and Experiment Station, and from 59 records taken in the Illinois region, all for the crop year 1915. Reference is made also herein to some of the facts obtained from 147 survey records taken by the Illinois Agricultural College and Experiment Station for the crop year 1912 in the same region of this State.

SYSTEMS OF SHARE RENTING.

THE HALF-AND-HALF SYSTEM.

The most common system of share rent of dairy farms in the regions studied, as elsewhere, is the so-called half-and-half system. Under this system the landlord furnishes land, buildings, the greater part of the seed and fertilizer, and half the productive stock, while the tenant furnishes horses, machinery, half the productive stock, part of the seed, and sometimes part of the fertilizer. All stock on these farms is fed usually from the grain and hay owned in common, and if feed of any kind is bought its cost is shared equally between landlord and tenant. In general, each party pays the taxes on all property owned by him, including the farm road tax, though in many cases in the North Central States all the farm road tax is worked out by the tenant.

Under this system the poultry frequently is owned exclusively, in limited numbers, by the tenant, he getting all the proceeds therefrom, but with this exception each party generally receives half of the proceeds of farm sales of all products of whatever nature.

In the best dairy region of Illinois, that contributing to the market milk of Chicago, the landlord in most cases owns all the cows, the tenant sharing half the loss by death or sales and the repurchases to keep up the herd. Sometimes, in this region, the tenant, instead of standing half the loss by death of a cow, gives the landlord a fixed amount, from $5 to $15 per head of cows dying.

THE ONE-THIRD AND TWO-THIRDS SYSTEM.

Less frequently dairy farms are share-rented on the one-third and two-thirds system. Under this system the landlord supplies everything but the man labor, which is furnished by the tenant. The landlord, under this system, gets two-thirds of the sales of all products and the tenant one-third, and in case feed and concentrates are purchased, the tenant pays one-third their cost.

SUMMARY OF RESULTS.

Following is a brief summary of the salient facts developed by this study and of the conclusions drawn from its results. While these facts and conclusions are believed to be very generally true of the regions studied, they are advanced here as being applicable only to the 143 representative farms surveyed.

CONDITIONS AND METHODS.

Variation in terms of rental.—With regard to what is furnished by the landlord, the chief difference between the farms of the Wisconsin group and those of the Illinois group is that in the Illinois group, in general, the landlord owns the cows and pays all the farm road tax, while in the Wisconsin group he owns but half the cows and pays only part of the road tax. The twine and thrashing bill is usually divided half and half in each region, but in the Wisconsin group the tenant more frequently pays the entire bill than does the Illinois tenant.

Length of lease period.—In the Wisconsin group, 76 per cent of the leases run for one year only, none being for a longer period than 3 years. In the Illinois group, 63 per cent of the leases are for 1 year and none for a longer period than 5 years. In the Wisconsin group 36 per cent and in the Illinois group 27 per cent of the leases are verbal.

Size and type of farm.—The average size of farm in the Wisconsin group is 201 acres, of which 140 is tillable and 84 in pasture. The average size of farm in the Illinois group is 184 acres, of which 139 is tillable and 58 in pasture. Corn, oats, timothy, and clover are the important crops of each region. Corn in the Wisconsin group occupies 37.4 per cent of the crop area, and in the Illinois group 51.4 per cent.

On the average farm of the Wisconsin group 25 cows are kept, while 43 are kept on the average farm of the Illinois group. The Wisconsin cows produce on the average dairy products to the value of $70 per head per year, while those of Illinois produce $94 worth.

Breeding of cows.—In the Wisconsin group, 74 per cent of the cows are grade Holsteins, and 51 per cent of the farms have pure-bred Holstein bulls. In the Illinois group, 56 per cent of the cows are grade Holsteins, and 53 per cent of the farms have pure-bred Holstein bulls.

Source of income.—Seventy-five per cent of the farm income on the farms of the Wisconsin group, and 85 per cent on those of the Illinois group, is from dairy cattle and their products.

Methods of maintaining herd.—In the Wisconsin group, 21.5 per cent of the cows were home-raised heifers that came fresh during the year, and 18.9 per cent of the herds were discarded or sold as dairy cows. The farmers here raise their cows instead of buying them. In the Illinois group, 8 per cent of the cows were home-raised

heifers with first calves, while 28.1 per cent of the herds were discarded, indicating that this is a dairy-cow purchasing region.

FACTORS INFLUENCING PROFITS.

Disposition of milk.—In the Wisconsin group, both landlord and tenant make least on farms selling butter fat, more on farms marketing milk through the cheese factory, and most on farms selling milk to condenseries. In the Illinois group, none of the milk was made into cheese and the profits were about the same, both to landlord and tenant, whether the milk was sold to the condensery or for market.

Breeding of cows.—The introduction of pure-bred cows in the dairy herd in the Wisconsin group is very profitable both to landlord and tenant, but it seems to be profitable only to the tenant in the Illinois group.

Length of tenure and of lease period.—In both the Wisconsin and Illinois groups the tenant remained on the farm longer under the yearly lease than he did where the lease was for a longer period.

REGIONS STUDIED.

GREEN COUNTY, WIS.

The counties ranking highest in dairy products in Wisconsin, according to the last census, are, in order, Dodge, Sheboygan, Dane, Walworth, and Green. However, in average sales of dairy products per farm, Green County, with $763, is the highest for the State. Tenancy in Green County is 28.6 per cent, of which about three-fifths is share. Nearly all the share-rented farms in this county are purely dairy farms and the rental system is well established. The landlord furnishes the land, buildings, half the cows and productive stock, most of the grass seed, pays about half the expense for thrashing and twine, sometimes all the road tax, and frequently furnishes the tenant fuel wood from the farm. The tenant furnishes the labor, horses, machinery, half the cows and other productive stock, sometimes part of the grass seed, and usually pays half the expense for thrashing and twine. On only 2 farms out of 84 did the landlord go to any expense for labor, in both of which cases he pays half the expense for hired labor. In all cases except two the horses, as well as the productive stock, are fed from grain and hay owned in common, half by each of the contracting parties. The proceeds from the sales of all farm products are divided equally between landlord and tenant, usually at the bank.

Dairy products are the principal source of income on the farms in Green as well as in many of the other counties of Wisconsin. In this county milk is marketed mostly at the condensery or through the cheese factory, and the haul usually is short. In a few cases, however, the haul to the condensery is 7 or 8 miles. The condenseries usually take nearly all the milk within a radius of about 3 miles

around them. Farmers who market their milk through the cheese factory usually have the cows freshen in the spring, and thus they produce most of their milk in the summer, while the cows are on pasture. In the winter, during December, January, and February, the cows are dry and the cheese factories are closed. On the other hand, the farmers who sell to the condensery usually have their cows freshen in the fall and aim to have them at the point of greatest production during January and February, when milk is highest in price. The cattle are on pasture usually from about May 10 to November 10. It is the general custom to sell such calves as are not raised at the age of from 2 to 4 weeks. More than enough cows to replenish the herd loss are raised, the surplus being sold to other dairy districts.

The data upon which is based the discussion in the following pages concerning Wisconsin farms were obtained in the winter of 1915–16 for the crop year 1915, in cooperation with the Wisconsin Agricultural College. Records were taken on 84 purely half-share-rented dairy farms.

KANE COUNTY, ILL.

This county ranks second in the State in production of dairy products, both as to total and as to average per farm, being outranked only by McHenry County, which lies just to the north of it. The average sales of dairy products per farm for McHenry County in 1909 were $1,064, and for Kane County $1,051. In 1909, 46.1 per cent of the farms of Kane County were rented, about one-third of them on shares.

These counties are in the famous Fox River or Elgin district, where dairying had its impetus years ago in the manufacture of creamery butter. Now the chief sources of revenue from milk are the condensery and the Chicago market.

In Kane County, on share-rented dairy farms, the landlord furnishes the land, buildings, usually all the cows, half the other productive stock, usually half the grass seed, and pays half the expense for thrashing and twine. Here the landlord also pays the road tax in cash, with his other real estate taxes. The tenant supplies the labor, horses, machinery, half the productive stock except cows, sometimes half the grass seed, and pays half the expense for thrashing and twine. He usually must pay half the loss on cows, whether by death or by sale of unsatisfactory cows and the purchase of others in their stead. Frequently the tenant does not bear half the loss on the death of a cow, but is under agreement on such occasions to pay the landlord a specified amount, ranging from $5 to $15. Loss or gain on the bull, generally gain, is shared equally. Often the bull is loaned to the partnership by a cattle dealer for his keep.

Some tenants have the privilege of raising one colt, but sometimes when colts are raised the tenant must turn into the herd one heifer

for each colt. The receipts from sales of all farm products are divided half and half, excepting sometimes those from fowls, which frequently are owned in a limited number exclusively by the tenant. All stock is fed from grain and hay owned in common.

Dairying in this region is of the intensive type. As will be seen later, few cows are raised and the calves usually are sold almost as soon as the mother's milk is marketable.

Fifty-nine records were taken in the region about Elgin, mostly in Kane County, for the crop year 1915. The data thus procured will be discussed in these pages, and reference will be made also to the data secured from 147 share-rented farms for the crop year 1912 by the Illinois Agricultural College, and loaned to the Federal department for use in this connection.

Figure 1 shows the locations in which these records were taken.

VARIATION IN DUTY OF LANDLORD AND OF TENANT.

Considerable variation was encountered in the duty of landlord and of tenant under the terms of the various contracts found in vogue (see Table I).

TABLE I.—*Items furnished by landlord and by tenant on 143 half-share rented dairy farms in Wisconsin and Illinois.*

[Figures show number of farms on which each specified item was furnished.]

Item.	Green County, Wis. (84 farms).			Kane County, Ill. (59 farms).		
	By landlord.	By tenant.	Half and half.	By landlord.	By tenant.	Half and half.
Horses	1	67	16	.....	59	.....
Machinery	3	70	11	.....	56	3
Cows	3	.....	81	49	.....	10
Grass seed	51	1	32	26	.....	33
Road tax	31	51	2	59	.....	.....
Twine	.....	19	65	3	2	54
Thrashing	.....	15	69	.....	2	57
Chickens	4	25	55	1	24	34
Milk cans [1]	2	72	10	3	13	37

[1] On the other 6 farms in the Illinois region the milk cans were furnished by the milk buyer.

It will be noted from the table that on the farms of the Wisconsin group the horses are owned mostly by the tenants and on those of the Illinois group they are all owned by the tenants. Likewise, the implements and machinery are owned mostly by the tenant, but to a greater extent on the farms of the Illinois group than those of the Wisconsin group.

The greatest variation in the division of expenses is in regard to cows and the payment of the farm road tax. In the Wisconsin group only three of the landlords own cows, and they are owned half-and-half on 81 farms, while in the Illinois group they are owned by the landlord on 49 farms and half-and-half on only 10 farms. As

stated previously, when the cows are owned by the landlord the tenant shares half the loss through sales and purchases, and either half the loss by death or a fixed amount ranging from $5 to $15 per cow.

On the 147 farms in this region from which records were taken by the Illinois station for the crop year 1912 in 139 cases the horses were supplied by the tenant and in 8 cases they were owned half-and-half. The machinery was owned in 126 cases by the tenant and in 21 cases half-and-half, and the cows were owned in 130 cases by the landlord, in 2 cases by the tenant, and in 15 cases half-and-half. The expenses for seed, thrashing, and twine in 1912 also were borne in about the same ratio as exhibited in Table I. Thus it would appear that the relation between landlord and tenant in this region has not changed materially during the last four years.

Under the type of lease most commonly found the duties and remuneration of the landlord and of the tenant, respectively, may be roughly outlined, first for the Wisconsin group, and then for the Illinois group, as follows:

Duties and remuneration of landlord and tenant, respectively.

WISCONSIN GROUP

Landlord:

Receives—

Half the returns from all farm products sold.

Pays—

Depreciation on buildings and on half the cows.
For repairs on buildings and fences and material for repairs.
Taxes on land, buildings, and on half the productive stock.
Insurance on farm buildings and on half the cows and other productive stock.
Half the cost of thrashing and twine.
For most of the grass seed.
Part of the road tax.
For half of the feed purchased.

Tenant:

Receives—

Half the returns from all farm products sold.

Pays—

Cost of all farm labor.
For all work stock, machinery, and tools.
For labor for rough repairs to buildings and fences.
Taxes and insurance on horses and machinery, and on half the productive stock, including cows.
Depreciation and repairs on machinery and tools.
Depreciation on horses and half that on cows.
Most of the farm road tax.
For half of the feed purchased.
For part of the grass seed.
Half the cost of thrashing and twine.
Cost of milk cans.

ILLINOIS GROUP.

Landlord:

Receives—

Half the returns from all farm products sold.

Pays—

Depreciation on buildings and on half the cows.
For repairs on buildings and fences and materials for repairs.
Taxes on land, buildings, cows, and half of other productive stock.
Insurance on farm buildings and on half the productive stock.
For most of the grass seed.
Half the cost of thrashing and twine.
All of the road tax.
For half of the feed purchased.
For part of the milk cans.

Tenant:

Receives—

Half the returns from all farm products sold.

Pays—

Cost of all farm labor.
For all work stock, machinery and tools.
For labor for rough repairs to building and fences.
Taxes and insurance on horses and machinery and on half the productive stock, except cows.
Depreciation and repairs on machinery and tools.
Depreciation on horses and half that on cows.
For half the feed purchased.
For part of the grass seed.
Half the cost of thrashing and twine.
For most of the milk cans.

FACTORS OF EFFICIENCY.

LENGTH OF LEASE PERIOD AND CHARACTER OF LEASE.

TABLE II.—*Length of lease period and character of lease.*

Item.	Length of lease period.			
	1 year.	2 years.	3 years.	5 years.
Number of Wisconsin dairy farms (total 84)	64	6	14	.....
Percentage of all leases	76	7	17	.....
Number of verbal leases	29	.....	1	.....
Number of Illinois dairy farms (total 59)	37	1	13	8
Percentage of all leases	63	2	22	14
Number of verbal leases	16	.....	.....	.....

As will be seen from Table II, most of the leases on the farms of both groups are for 1 year; in the Wisconsin group none are for a longer period than 3 years, and in the Illinois group none for a longer period than 5 years. About one-third of the leases on the farms of the Wisconsin group and about one-fourth of those in the Illinois group are verbal. In general, these leases are automatically renewed unless one of the parties gives notice to the contrary.

BREED OF COWS.

TABLE III.—*Breed of cows.*

Item.	84 Green County, Wis., farms.		59 Kane County, Ill., farms.	
	Number of farms.	Per cent of all farms.	Number of farms.	Per cent of all farms.
Farms having all pure-bred cows (all Holstein)	3	4	.....	.....
Farms having part pure-bred cows	9	11	4	7
Farms having grade Holstein cows	62	74	33	56
Farms having cows of mixed grade	10	12	22	37
Farms having pure-bred bulls	46	55	31	53
Farms having pure-bred Holstein bulls	43	51	31	53

From Table III it is seen that on a few of the farms of the Wisconsin group the cows are all pure bred, while on none of those of the Illinois group are they all pure bred. The dominant breed of cow in both regions is the Holstein and more than half of the farms in the groups from each State have pure-bred Holstein bulls.

SOURCES OF INCOME.

The regions in which these records were taken are distinctly dairy regions. Though on some of the Wisconsin farms studied a large part of the farm income is derived from the sale of hogs, in no other section of the United States, with the probable exception of several New York and New Jersey counties, is the farm income so largely derived from the sale of dairy products as in the regions under discussion. The extent to which the farm income is dependent on dairy products in this region will be seen from Table IV. For purposes of comparison the per cent of farm income from various products in several other regions is given.

TABLE IV.—*Sources of farm income on Wisconsin and Illinois share-rented dairy farms, compared with Illinois stock farms, Texas cotton farms, and Pennsylvania dairy farms.*

[Per cent of receipts.]

Sources of farm income.	Share-rented farms.			Cotton farms.	General.
	84 dairy farms in Green County, Wis.	59 dairy farms in Kane County, Ill.	124 dairy farms in Chester County, Pa.	115 farms in Ellis County, Tex.	73 central Illinois stock farms.
Dairy cattle and their products	75	85	54	0	3
Other stock	[1] 20	6	3	6	[2] 57
Poultry and eggs	2	2	8	0	2
Corn	0	0	2	2	19
Wheat	0	3	8	0	11
Oats	0	1	0	1	4
Rye	0	1	0	0	0
Hay	0	1	11	2	0
Potatoes	0	0	7	0	0
Cotton	0	0	0	86	0
Miscellaneous	3	1	7	3	4
Total	100	100	100	100	100

[1] From hogs, 19 per cent.

[2] From beef cattle, 24; hogs, 28; horses, 5 per cent.

Where zero appears after a source of income, the receipts from it were less than 1 per cent. Several other sources of income, the receipts from which were less than 1 per cent, are included in the miscellaneous receipts.

Seventy-five per cent and 85 per cent, respectively, of the farm income on the share-rented farms of Wisconsin and Illinois studied was from dairy cattle and their products, while but 54 per cent of the income from such farms in Chester County, Pa., was from this source. For comparison as to sources of income, the table shows that 86 per cent of the income from the average of 115 farms in Ellis County, Tex., is from the single crop, cotton, and that 57 per cent of the average of 73 central Illinois stock farms comes from live stock.

SIZE AND CROP AREAS OF FARMS.

TABLE V.—*Size and crop areas of farms.*

SIZE.

Item.	Average of 84 Wisconsin farms.		Average of 59 Illinois farms.	
	Acres.	Per cent of total area.	Acres.	Per cent of total area.
Land in farm	201	100	184	100
Tillable area	140	70	139	75
Land in pasture	84	42	58	32
Land in farmstead, woods, roads, etc	16	8	10	5
Land in crops	102	51	116	63

CROP AREA.

Crop.	Acres.	Per cent of crop area.	Acres.	Per cent of crop area.
Corn	38.2	37.4	59.6	51.4
Oats	21.7	21.2	23	19.9
Wheat	.4	.4	4.1	3.5
Rye	1.7	1.6	1.4	1.2
Barley	5.1	5	3.5	3
Timothy and clover	23.9	23.4	18.7	16.2
Alfalfa	9.3	9.1	5.2	4.5
Wild hay	1.2	1.2	.....	.....
Fruit (apples)	.3	.3	.2	.2
Potatoes	.2	.2	.2	.1
Total	102	100	116	100

The average size of the farms of the Wisconsin group is 17 acres greater than that of the farms of the Illinois group. (See Table V.) A greater percentage of the land in the Illinois group of farms is tillable and in crops and a less percentage is in pasture than on those of the Wisconsin group.

Corn is the chief crop in each area. The crops occupying the next greater acreages are hay and oats. In the Wisconsin area, 9.1 per cent of the crop area is in alfalfa, the limestone soils of the hilly sections of Green County being well adapted to this crop, while in the

Illinois area only 4.5 per cent of the crop area, or 5.2 acres per farm, was in alfalfa. In 1912, as shown by 147 records taken in the Illinois area by the Illinois station, the average area of alfalfa per farm was only 1.5 acres.

In general, the dairying practiced in the Illinois group is of a more intensive character than that practiced in the Wisconsin group, and much more feed and concentrates are purchased. The average feed bill on the Illinois farms was $656, or $11 per animal unit,[1] while that on the Wisconsin farms was only $182, or $3 per animal unit.

INVESTMENT AND EARNINGS.

TABLE VI.—*Comparison of average investment, earnings, etc.*

Item.	Average of 84 Wisconsin farms.	Average of 59 Illinois farms.	Item.	Average of 84 Wisconsin farms.	Average of 59 Illinois farms.
Value of real estate per acre	$128	$173	Monthly cost of man labor	$39.06	$36.06
Landlord's working capital	$2,169	$3,564	Months of man labor	24	33
Landlord's total capital	$27,852	$35,477	Crop acres per animal unit	2	1.9
Per cent earned on landlord's investment	3.9	4.6	Pasture acres per animal unit	1.6	1
Tenant's total capital	$3,184	$2,419	Age of tenant	34	41
Tenant's labor income[1]	$730	$1,023	Age of landlord	55	59
Cows per farm	25	43	Years farm has been rented	8.5	16.8
Dairy products per cow	$70	$94	Years tenant has rented	5.8	9.8
Cows per man	12.5	15.4	Years tenant has rented this farm	3.7	5.7

[1] In computing the labor incomes for this bulletin, interest at the rate of 5 per cent was allowed on the tenant's capital.

From Table VI it is seen that the average investment of the landlord per farm is greater in the Illinois group than in the Wisconsin group. The tenant's capital, however, is larger on the Wisconsin farms for the reason that in most cases he owns a half interest in the cows, whereas in Illinois he does not. In Wisconsin the landlord makes 3.9 per cent on his investment, in Illinois 4.6 per cent. The labor income of the tenant was likewise larger in the latter State ($1,023 as against $730). This greater profit to both landlord and tenant on the Illinois farms may be accounted for in part by the fact that the farm enterprise, although covering a smaller acreage, was larger on the average in the Illinois group than in the Wisconsin group and that in Illinois the farmers were in a market-milk selling region.

The reason the Illinois farmers have to buy more feed is seen in the fact of their having fewer crop acres and pasture acres per animal unit.

[1] An animal unit is a mature horse or cow or as many smaller animals as require the feed of a horse or cow, namely, 2 head of young cattle, 5 hogs, 7 sheep, or 100 hens.

ANNUAL CHANGES IN COWS.

TABLE VII.—*Sales, additions, and casualties affecting herds.*

	Average of herds on 84 Wisconsin farms (25 cows per farm).		Average of herds on 59 Illinois farms (45 cows per farm).	
	Number.	Per cent of herd.	Number.	Per cent of herd.
Added to herd:				
Heifers fresh during year	5.4	21.5	3.4	8.0
Cows bought	.7	2.8	9.6	22.2
Total	6.1	24.3	13.0	30.2
Removed from herd:				
Cows died	.3	1.2	.7	1.6
Cows sold	4.4	17.7	11.2	26.0
Total	4.7	18.9	11.9	27.6
Excess of additions over removals, or herd increase	1.4	5.4	1.1	2.6

From Table VII it is seen that a greater percentage of the herds were heifers that came fresh during the year on the farms of the Wisconsin group than on those of the Illinois group, and that a much larger percentage of the herd was bought and sold on the farms of the latter than on those of the former State. Many of the cows sold from the group of Wisconsin farms were good dairy cows, while those sold from the Illinois group of farms were mostly unprofitable milk producers.

The yearly percentage of deaths of dairy cows on 453 farms in Lenawee County, Mich., as determined by a farm management survey, was 1.7, and on 643 farms in Chester County, Pa., 1.3. These figures do not differ much from those for Wisconsin and Illinois groups under consideration. The proportion of cows discarded per year on the farms investigated in Lenawee County, Mich., was 21.6 per cent, and in Chester County, Pa., 23 per cent. These figures are greater than those for the Wisconsin group and less than those for the Illinois group. From the foregoing figures it is seen that the length of time the average cow remains in these herds is 5.3 years for the Wisconsin group, 4.6 years for the Michigan group, 4.3 years for the Pennsylvania group, and 3.6 years for the Illinois group.

RELATION OF FARM PRACTICES TO PROFITS.

INFLUENCE OF KIND OF DAIRY PRODUCTS SOLD ON PROFITS.

The source of income on the farms in both groups, as previously shown in Table IV, is mainly dairy products. Table VIII shows the profits of landlord and of tenant in relation to the kind of dairy products sold.

TABLE VIII.—*Relation of kind of dairy products sold to profits.*

[Average figures.]

Item.	84 Wisconsin farms.			59 Illinois farms.	
	3 farms selling butter fat.	49 farms selling milk to cheese factory.	32 farms selling milk to condensery.	33 farms selling market milk.	26 farms selling milk to condensery.
Average total capital	$22,496	$29,879	$33,609	$37,977	$37,794
Average size farms (acres)	179	206	195	182	187
Average number of cows	18	23	29	39	47
Average dairy receipts per cow	$56	$64	$77	$96	$91
Average receipts from hogs	$656	$795	$352	$147	$173
Tenant's average labor income	$413	$677	$842	$1,038	$1,004
Average per cent on landlord's investment	3.3	3.9	4	4.6	4.6

Both tenant's labor income and landlord's profits are least on the Wisconsin farms selling butter fat ($431 and 3.3 per cent), and most ($842 and 4 per cent) on the group of farms selling milk to the condensery. The per cent the landlord makes on his investment in the Illinois group is 4.6, both where the milk is sold on the market and where it is sold to the condensery, and the tenant's average labor income is practically the same in the two groups. None of the Illinois farms visited sold butter fat.

RELATION OF BREEDING OF COWS TO PROFITS.

Whether the cows are grade or pure bred is frequently the deciding factor in reference to profits on dairy farms. The influence of breeding on the profits of the landlord and of the tenant on these farms is shown in Table IX.

TABLE IX.—*Influence of breeding of cows on profit.*

Item.	84 Wisconsin farms.				59 Illinois farms.		
	3 farms with pure-bred Holstein cows.	9 farms with part pure-bred Holstein cows.	62 farms with grade Holstein cows.	10 farms with mixed or other grade cows.	3 farms with part pure-bred Holstein cows.	34 farms with grade Holstein cows.	22 farms with mixed or other grade cows.
Total capital	$42,615	$41,318	$30,652	$20,689	$38,279	$39,542	$35,301
Land in farms (acres)	163	206	205	186	148	192	176
Number of cows	22	33	25	20	33	43	43
Per cent of cows raised	20	26	20	15	19	9	5
Dairy receipts per cow	$99	$83	$69	$42	$103	$92	$96
Labor income	$1,368	$1,164	$716	$234	$1,059	$1,041	$989
Landlord's per cent on investment	5.7	5	3.6	2.8	3.7	4.6	4.8

In the Wisconsin area only three farms had pure-bred cattle exclusively, and in the Illinois area only three farms had part of the herd pure bred. This number, although averaged in the table in each case, is not great enough to give a reliable average. On two of

the three Illinois farms having part pure-bred cows, the land was valued particularly high and the business was comparatively smaller. For these reasons, the percentage on the landlord's investment appears low in the table. However, the labor income in the Wisconsin area rises from $234, on farms where mixed-grade cows are kept, gradually to $1,368 where all the cows are pure bred; and in the Illinois area also it rises from $989 on farms where the cows are of mixed grade to $1,059 on farms where the cows are part pure bred. This shows definitely that the introduction of pure blood into the herd increases the profit of the tenant. In the Wisconsin area the landlord's percentage on his investment rises from 2.8 on the farms where the cows are of mixed grade, through 3.6 where they are grade Holsteins, and 5 where they are part pure bred, to 5.7 per cent where they are all pure-bred Holsteins. For the reason stated above, no conclusion can be drawn concerning the profitableness to the landlord of maintaining pure-bred herds in the Illinois region, but it is evident that on the farms in question the raising of pure-bred cows was more profitable in the Wisconsin group than in that of Illinois.

INFLUENCE OF THE SHORT AND LONG TERM LEASE ON LENGTH OF TENURE.

With a view of exhibiting the effects of the short and of the long term lease on the length of individual tenure, Table X was prepared.

TABLE X.—*Relation of short- and long-term leases to length of tenure.*

Item.	Years in lease period.						
	84 Wisconsin farms.			59 Illinois farms.			
	1	2	3	1	2	3	5
Number of farms	64	6	14	37	1	13	8
Number of farms, averaged	64	20		38		21	
Years on this farm	4.2	2.2		7		4.4	

It is seen from the table that in both groups the average length of time the tenant has been on the farm is longer on farms with short-term leases than it is on farms with long-term leases.

In the Wisconsin group tenants with 1-year leases had been on the farm an average of 4.2 years, while those with longer-term leases had been on the farm an average of only 2.2 years. Likewise, in the Illinois group tenants with short-term leases had been on their farms an average of 7 years, while those with long-term leases had been on their farms an average of but 4.4 years.

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BULLETIN No. 604

Contribution from the Forest Service
HENRY S. GRAVES, Forester

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INCENSE CEDAR.

By J. Alfred Mitchell, *Forest Examiner.*

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COMMERCIAL IMPORTANCE.[1]

Incense cedar (*Libocedrus decurrens* Torrey) is comparatively little known on the general market. Only the better grades of lumber are shipped, and not much of this material is produced, owing to the prevalence of "peckiness" or "dry-rot," and to the scattered occurrence of the tree. Frequently it is mixed with other species, there being too small a quantity of it produced in most operations to be handled separately. The local market for it is extensive, however, and it is cut by practically every operator in the mountains of California and southern Oregon, along with the more valuable timber trees with which it grows.

An inquiry among the operators and dealers throughout California in 1912 showed that the total cut for that year, including local consumption, was, in round numbers, 32,810,000 board feet. Table 1 gives the cut in California from 1899 to 1916, exclusive of local consumption, and the value of the cut at prevailing wholesale prices where available.

[1] Acknowledgment is made of the valuable assistance rendered in the gathering of data for this publication by various Forest officers of Districts 5 and 6, whose hearty cooperation has made its preparation possible, and of the assistance of Dr. E. P. Meinecke and Messrs. T. D. Woodbury, C. A. Kupfer, Ralph Hopping, and L. T. Larsen in the compilation of the data and the revision of the manuscript.

TABLE 1.—*Annual production of incense cedar, as reported, and its value at prevailing market prices.*[1]

Year.	Total cut of incense cedar reported.	Average mill-run price.	Total value.
1899[2]	4,882,000	.....	.....
1900	4,049,000	.....	.....
1901	3,550,000	.....	.....
1902	2,424,000	.....	.....
1903	5,478,000	.....	.....
1904	3,157,000	.....	.....
1905	3,043,000	.....	.....
1906	2,876,000	.....	.....
1907	7,018,000	.....	.....
1908[3]	12,790,000	$10.52	$134,551
1909	14,834,000	12.95	192,100
1910	20,846,000	12.80	266,829
1911	16,993,000	11.39	193,550
1912	18,507,000	.....	.....
1913	22,056,000	.....	.....
1914	17,872,000	.....	.....
1915	12,185,000	12.08	147,195
1916	16,587,000	13.05	215,416

[1] Incense cedar forms less than 1 per cent of the total of all timber cut in California.
[2] Data for the years 1899–1907, inclusive, furnished by the California State Development Board.
[3] Data for 1908–1916, inclusive, from reports of the United States Bureau of the Census and the Forest Service.

PRODUCTS AND USES.

Incense cedar is chiefly valuable for its lasting qualities, its durability in contact with soil, and its peculiarities of grain and texture. Its durability was early discovered by settlers and prospectors, as is shown by its extensive use for rails, fence posts, and foundation timbers. Telephone and telegraph companies, railroads, and lumbermen also have recognized its good qualities and utilize it to a considerable extent for poles, stubs, flume timbers, ties, and the like, wherever it is available. Recent developments have shown its adaptability to certain special uses, and a growing demand has sprung up that promises to make this an important Pacific coast species in spite of its characteristic unsoundness and past unpopularity. Table 2 indicates the extent to which incense cedar is used by manufacturers and Table 3 how the total cut of 1912 was divided among various uses.

TABLE 2.—*Consumption of incense cedar by the wood-using industries.*

Industry.	Quantity used annually.		Cost f. o. b. factory.	
			Average per 1,000 feet.	Total.
	Feet b. m.	*Per cent.*		
Pencil slats	3,050,000	52.5	$18.00	$54,900
Doors and sash	2,570,000	44.2	17.75	45,620
Chests and boxes	93,750	1.6	25.00	2,344
Flooring and moldings	62,500	1.1	25.00	1,563
Raisin trays	31,250	.6	16.50	516
Total	5,807,500	100.0	18.07	104,943

NOTE.—See Bulletin No. 3, California State Board of Forestry, "Wood-using Industries of California," by Andrew K. Armstrong, engineer in timber tests, U. S. Forest Service, 1912.

TABLE 3.—*Consumption of incense cedar in 1912, classified by products.*

Use.	Quantity used.		Market price or value.		Total value.
			Range.	Average.	
	Feet b. m.	*Per cent.*			
Lumber	22,500,000	68.6	$10 to $75 per 1,000 feet	$15 per 1,000 feet[1]	$337,500
Ties	3,500,000	10.6	20 cents each	20 cents each	20,000
Pencil slats	3,050,000	9.2	$14.50 per 1,000 feet[2]	$14.50 per 1,000 feet[2]	44,225
Posts	2,500,000	7.6	10 to 35 cents each	18 cents each	35,226
Poles and stubs	500,000	1.5	Stubs, 30 cents Poles, $1.25 to $4.50	30 cents $1.50	3,900
Cordwood	500,000	1.5	$4.50 to $6.50 per cord	$5.50 per cord	5,500
Shingles	250,000	.7	$2.50 to $5 per 1,000 feet	$3.75 per 1,000 feet	7,500
Shakes	10,000	.3	$7 per 1,000 feet	$7 per 1,000 feet	210
Total	32,810,000	100.0			454,061

[1] Mill run No. 2 common or better.
[2] 2⅝-inch rough, f. o. b. cars at main-line points.

LUMBER.

Incense cedar when sound makes excellent lumber, for it is light, soft, and easily worked. It is not, however, a good lumber-producing tree, because of its short body, rapid taper, and susceptibility to "dry-rot" or "peckiness." So common is this that it is a common practice in cruising incense cedar to deduct from 30 to 50 per cent for cull on account of it. Only the occasional sound trees and portions of logs free from dry-rot are sawed into boards, the rest, unless too badly honeycombed, being cut into dimension stuff or ties.

The yield of various grades of lumber from an incense cedar tree depends very largely, of course, on the amount of "dry-rot." This varies so widely, however, in different trees in one locality as well as in trees in different localities that data based on the yields of "pecky" trees would have very little general application. The yields indicated in Table 4 are based therefore on sound trees and are fairly typical of the yield where there is no "dry-rot."

TABLE 4.—*Yield by grade of incense-cedar lumber.*

Grade.	Tree No. 1.		Tree No. 2.	
	Yield in board feet.	Per cent.	Yield in board feet.	Per cent.
Clear	500	17	1,360	17
No. 1 common	900	31	2,340	29
No. 2 common	700	24	1,890	24
No. 3 common	500	17	1,350	17
Cull	300	11	810	13
Total	2,900	100	7,750	100

The price of rough incense cedar lumber, mill run, averages $15 per thousand feet board measure at the mill. The prices paid for it in its manufactured form at centers of distribution and consump-

tion, however, vary widely with its quality and the use for which it is desired. As high as $75 per thousand feet board measure has been paid for select uppers, to be used as pattern stock and in cabinet work; but it is often difficult to dispose of the lower grades at $8 or $10 per thousand, prices which scarcely pay the cost of logging and manufacture. Table 5 shows the range of prices as they were quoted in 1912, and the average prices for the different grades.

TABLE 5.—*Selling price of incense cedar, by grades, f. o. b. mill in 1912.*

Grade.	Range.	Average.
Clears	$30 to $75 per 1,000 feet	$45 per 1,000 feet b. m.
No. 1 common	$22 to $32 per 1,000 feet	$27.50 per 1,000 feet b. m.
No. 2 common[1]	$18 to $22 per 1,000 feet	$20 per 1,000 feet b. m.
Mill run	$10 to $20 per 1,000 feet	$15 per 1,000 feet b. m.

[1] Grades lower than No. 2 common are usually unmerchantable.

The greater portion of the cedar that finds its way into the general market is used by builders for outside trim and interior finish. Its durability, easy working qualities, pleasing grain, rich color, and ability to take a good polish make it particularly desirable for these purposes. Sash and door manufacturers use it to some extent because of its availability and cheapness, although in the aggregate it amounts to but 2 per cent of the total quantity of lumber consumed by this industry. It is used also in the manufacture of chests and wardrobes, the aromatic odor of the wood supposedly rendering them moth-proof. A small quantity is consumed annually for pattern stock, moldings, and raisin trays. Locally, incense cedar is used for dimension stuff and rough construction work, or for sills, culverts, sidewalks, bridge planks, etc., where cheapness or durability are important and the presence of dry-rot does not affect its usefulness.

Cedar is used occasionally in the manufacture of crates and fruit boxes, but owing to its tendency to split in nailing it is considered undesirable. An attempt also has been made to utilize it in the manufacture of cigar boxes, but it was found that the oils contained in the wood imparted a disagreeable flavor to the cigars.

TIES.

In the early nineties there was a considerable demand for incense-cedar ties, and large numbers were hewn in Eldorado, Placer, and Nevada Counties. These ties brought 25 cents each and found a ready market at San Joaquin Valley points, where railroad construction was then under way. As the size and weight of rolling stock increased, cedar was found to be too soft to stand the wear and tear, and its use was abandoned, except for logging roads and spurs where

this was not excessive. To-day, however, with the universal use of tie plates, cedar ties are again coming into more general use in regions where they are available.

PENCIL SLATS.

Although the use of incense cedar for pencil slats is of recent development it bids fair to become more and more important as the supply of southern red cedar becomes exhausted. As is shown in Table 2, the demand of pencil manufacturers for incense cedar has already surpassed that of all other industries.

The qualities of incense cedar which adapt it particularly to this use are its softness, its straight grain, and the ease with which it can be whittled. While its color is not all that could be desired, it stains readily and is highly satisfactory for the cheaper grades of pencils. Dry-rot does not affect its usefulness for this purpose except by increasing the necessary cull, for the sound wood between the cavities caused by the rot can be utilized to a great extent. Some trouble has been experienced with uneven shrinkage in kiln drying after staining, particularly when the wood showed rapid growth. This, however, is a minor difficulty, as cedar is characteristically a slow-growing tree.

Cedar for pencils ordinarily is contracted for by the pencil manufacturers at so much per 1,000 feet board measure, delivered aboard the cars at main-line points. In such cases it usually is bought direct from timber operators. Occasionally, however, stumpage is purchased and the logging contracted for. Pencil wood was formerly shipped in the log, the logs first being peeled; but recently this practice has largely been discontinued, the logs now being sawed into planks of the desired thickness locally and shipped to slat factories as rough lumber. This allows closer culling and reduces freight charges. At the slat mills, usually located at some central shipping point, the cedar is first seasoned and then cut into slats of the desired size; these slats are later sorted, stained if necessary, bundled, and shipped to factories in the East or in Europe for manufacture into pencils.

Cedar suitable for pencil stock brings from $10 to $12.50 per thousand feet board measure in the log and $14.50 per thousand when sawn into planks f. o. b. cars at main-line points, which, while low for lumber in general, is an average price for cedar, when the amount of cull is considered.

POSTS, RAILS, POLES, AND STUBS.

The durability of incense cedar in contact with the soil, its lightness, and the ease with which it splits make it particularly desirable

as a post timber. Few species are prized more highly for this purpose. Since the days of the earliest settlers it has been the chief source of fence posts and rails throughout the mountains and foothills of California.

Posts and rails for the most part are split, the trees first being felled and bucked into the desired lengths. Although in a few cases cedar has been sawed into 4 by 4s or 4 by 5s for this purpose, split posts generally are considered more satisfactory. In good timber two men working together can split out 200 or more posts a day, thus making good wages at from 5 to 6 cents a post, the usual price paid for this work.

In making posts usually the heartwood only is utilized, the sapwood not being durable. Post makers prefer dead and charred cedar logs and snags where the sapwood has rotted and been burned away, leaving thoroughly seasoned heartwood. Such material is usually sound, for if dry-rot had been present in any considerable quantity the entire log would have burned.

It is estimated that at least 230,000 incense cedar fence posts are used annually. Accurate figures, however, are not obtainable, since their use is for the most part local and they are cut in small lots, often by the men who use them. On the National Forests cedar posts form an important item of the free-use business, most of the local ranchers obtaining their supply in this way. In some regions it is an annual custom for those located in the foothills to go into the mountains for a week or two each fall for the purpose of cutting and hauling their year's supply of posts and rails.

The stumpage value of post material varies from 2 to 6 cents per post, according to its accessibility and abundance, dead cedar usually bringing about 1 cent less than green, although it is the more desirable of the two. Throughout the Sierras the price ranges from 2 to 4 cents, except on the Nevada slope, where it is somewhat higher because of its scarcity. The prices at which posts are sold, ranging from 10 to 35 cents, are given in Table 3. This variation, however, is due largely to differences in the cost of transportation to the various market points rather than to differences in the cost of stumpage or manufacture. In the local markets, which consume most of the supply, from 16 to 18 cents is the usual price.

Table 6, based on somewhat limited data, indicates roughly the yield in posts for trees of various diameters. There is, however, such a great variation in the relative width of the sap, the ease of working, and the waste due to rot and knots, that at best a table of this character is only approximate.

TABLE 6.—*Post volume table for incense cedar; basis, 8 trees.*

Diameter, breast-high.	Number of posts.	Diameter, breast-high.	Number of posts.
Inches.		*Inches.*	
24	48	48	120
30	66	54	138
36	84	60	156
42	102		

Large numbers of poles and stubs also are made annually for local use. Like rails and fence posts, these are practically all split, although in a few instances sawed incense cedar poles have been used by power companies in their local lines. Such poles were quoted locally in 1911 at the prices given in Table 7.

TABLE 7.—*Local market prices of sawed incense cedar poles (1911).*

Dimensions.			Market price (each).
Butt.	Top.	Length.	
Inches.	*Inches.*	*Feet.*	
8 by 8	6 by 6	18	$2.35
8 by 8	6 by 6	20	2.50
9 by 9	6 by 6	25	3.50
10 by 10	7 by 7	30	4.50

Owing to the presence of dry-rot and the greater difficulties of transportation, incense cedar poles are not so desirable as poles of the western red cedar of the Northwest, and no attempt therefore has been made to put them on the general market. Split poles approximately 6 inches by 6 inches by 18 feet are frequently used in local telephone-line construction, and bring for this purpose from $1.25 to $1.50 each. The use of such poles, however, is not extensive, owing to the scarcity of timber from which they can be split. Round poles made from incense cedar saplings have also been used to a limited extent. They are not particularly satisfactory, however, owing to their rapid taper and to the preponderance of sapwood.

The extensive use of cedar stubs throughout California has arisen from the necessity of either replacing or stubbing poles which have rotted off at the ground. Stubbing, being the cheaper, has been the practice usually followed, a stout post being set alongside and the old pole wired or bolted to it. As cedar is handy and the most durable timber available, it is usually used for this purpose throughout its range. Though not quoted in the general market, cedar stubs sell locally for 30 cents in regions where the species is fairly abundant.

SHAKES AND SHINGLES.

Incense cedar shakes were used in considerable quantities in the early days by settlers and prospectors, but have been displaced by sugar pine, and to-day the use of cedar for this purpose is limited to an occasional tree cut by some miner or "sky" rancher.

The use of incense cedar for shingles is of considerable importance locally where the general market is not readily accessible. It makes an excellent shingle, but the small amount of sound timber available has prevented its being exploited as a shingle material. Throughout its range the small sawmills supplying the local market frequently cut shingles in limited quantities for home consumption. For this purpose cedar is usually sold in bolts by the cord, the stumpage price being about $1 per cord or $2 per thousand feet board measure. In the local market incense cedar shingles bring from $2.50 to $5 per thousand according to quality, averaging from $3.50 to $3.75. In one instance reported the prices quoted, per 1,000, were as follows:

No. 1 clear heart cedar	$5.00
No. 2 heart and sap	3.75
No. 3 sound knots	2.50

MISCELLANEOUS USES.

Among the various uses of incense cedar not mentioned above, its use as fuel is probably the most important, although the quantity consumed in this way is insignificant when compared with the total amount of fuel wood used annually. It burns readily, gives off considerable heat and but little smoke, and is frequently used where it is plentiful, being generally considered more desirable than pine. Its fuel value, according to Sargent, is 54 per cent that of white oak. In a number of logging operations it is used exclusively for cooking and heating around the camps. In 1911 and 1912 more than 1,800 cords of this species were cut in the vicinity of the Shasta National Forest and disposed of locally for $4 and $4.50 a cord. Ordinarily, however, little is sold; it is cut and used mostly by local inhabitants.

In the raisin country at the upper end of the San Joaquin Valley incense cedar is used extensively for grape stakes. These are split out in much the same manner as posts and are hauled down from the mountains in small quantities and disposed of to the vineyardists in the valley, who utilize thousands of such stakes annually. It is in this region, too, that incense cedar is used for raisin trays, its lightness, durability, and freedom from warping and checking making it particularly desirable.

Experiments have been conducted by the Forest Service at its Forest Products Laboratory, Madison, Wis., to determine the possi-

bilities of incense cedar as a pulpwood. These experiments[1] show that a fairly good grade of paper can be made from it, although somewhat dark in color and difficult to bleach. The available supply, however, in comparison with the more desirable pulpwood species, is too limited to admit of its ever assuming commercial importance for this purpose.

Among the miscellaneous uses for incense cedar is the use of the bark as a top dressing for dirt roads subject to heavy traffic. This is common in the vicinity of logging operations, where heavy hauling is necessary. The tough, stringy bark serves admirably to keep down the dust and reduce the wear and tear on the road. It also serves excellently as a binder where the ground is soft and springy. The bark, which somewhat resembles that of redwood, has also been used in the manufacture of souvenirs and novelties, although not on a commercial scale. Attempts have also been made to utilize it in the manufacture of matches, but it was found to be too brittle.

AVAILABLE SUPPLY.

COMMERCIAL RANGE AND OCCURRENCE.

The commercial range of incense cedar is confined to the west slope of the Sierra Nevadas and the mountains of northern California and southern Oregon, although the tree occurs throughout the mountains of the Pacific coast from central Oregon to northern Mexico. It is found only in mixture with other species, chiefly yellow pine, sugar pine, Douglas fir, and white fir, averaging in general about 8 per cent of the stand. Throughout most of its range a cut of 2,000 feet per acre is a fair average, but in localities particularly favorable to its growth it frequently runs from 4,000 to 7,000 feet to the acre and forms as much as 18 per cent of the merchantable timber. Cuts of from 13,000 to 20,000 feet to the acre have been reported on limited areas where it formed from 30 to 50 per cent of the total stand, but they are unusual. These variations in the proportion of incense cedar in the stand, as well as the stand per acre, are characteristic throughout its entire range, but in the southern Sierras, where the conditions for its growth are most favorable, the average stands are generally heavier and the maximum occurs more frequently. This is brought out by a comparison of the average proportion of incense cedar in the stand and the average stands per acre in different regions. For example, in northern California the average stand per acre is only about 500 feet, 4 or 5 per cent of the total stand; but in the southern Sierras it averages from 18 to 25 per cent and runs from 2,500 to 7,000 feet per acre.

[1] For the results of these tests see "Paper Pulp from Various Forest Woods," Forest Products Laboratory Series, U. S. Department of Agriculture, Forest Service. Issued Mar. 7, 1912.

ESTIMATED STAND.

In round numbers, the available supply of incense cedar in California is estimated at 10 billion feet board measure, and in Oregon and Nevada combined perhaps 1 billion more, or 11 billion feet in all. Of this, approximately one-half is privately owned, the rest being distributed among the various National Forests, parks, etc. Table 8 gives the estimated stand on the various National Forests in California and Nevada.

TABLE 8.—*Incense cedar on National Forests.*

National Forest.	Estimated stand.	Per cent of total.	National Forest.	Estimated stand.	Per cent of total.
	Feet, b. m.			*Feet, b. m.*	
Stanislaus	747,232,000	14.5	Eldorado	200,000,000	3.8
Sierra	731,177,000	14.2	California	198,666,000	3.8
Klamath	729,710,000	14.2	Cleveland	50,000,000	1.0
Sequoia	580,608,000	11.9	Angeles	47,587,000	.9
Plumas	500,000,000	9.7	Modoc	29,850,000	.6
Trinity	416,578,000	8.1	Santa Barbara	7,000,000	.1
Shasta	375,918,000	7.3	Mono	550,000	.....
Tahoe	300,000,000	5.8			
Lassen	215,000,000	4.1	Total	5,129,876,000	100

STUMPAGE VALUE.

The stumpage value of incense cedar on private lands, where it is sold with other species for lumber, varies from $2.50 per thousand, for pencil wood and select post material, to 25 cents per thousand. The average price per 1,000 feet board measure received in sales of incense cedar on the National Forests during the past 11 years are as follows:

1905 $0.25	1909 $1.25	1913 $0.60
1906 .45	1910 1.30	1914 .95
1907 .64	1911 1.50	1915 .80
1908 .88	1912 .92	

The value of the remaining stand, based on the prevailing stumpage price for incense cedar on National Forests in 1915, amounts to approximately $8,500,000 or $9,000,000. For special uses it is worth at least three times that amount to-day and is bound to become still more valuable in the future as the supply diminishes.

THE WOOD.

The wood of incense cedar bears closest resemblance both in gross and minute structure to the bald cypress and western red cedar. It is not likely, however, that incense cedar will be substituted for these woods, so that the question of identity will seldom be raised.

GROSS CHARACTERISTICS.

The wood of incense cedar is soft and light, averaging about 25 pounds per cubic foot in an air-dry condition. Its shipping weight is about 4,500 pounds per thousand feet board measure in the log, and from 2,300 to 2,500 pounds per thousand feet as lumber, depending upon the degree of seasoning. The wood, though not strong, is compact, and has a fine straight grain, splits readily and evenly, and does not check or warp much in seasoning. It works well, takes a good polish, is extremely durable, and is consequently useful in many ways. As the name implies, incense cedar is markedly aromatic, possessing a pronounced resinous and not unpleasant odor.

The sapwood and heartwood are usually well defined, especially in old trees and seasoned lumber. The sapwood is white or cream colored, and the heartwood a light brown, often tinged with red and turning darker with age and exposure to light and air.

The annual rings of growth, though sharply defined in structure, can not always be readily distinguished by the naked eye in slow-growing or suppressed trees and in the outer portion of old, overmature timber, where the rings are narrow. In thrifty growing trees, however, the annual rings put on in early life are often wide and fairly conspicuous.

STRENGTH AND SHRINKAGE.[1]

Incense cedar is not strong when compared with longleaf pine and Douglas fir, owing to the prevalence of defects and its low elastic limit. Figures on its actual strength value for construction purposes are not available, but Table 9 contains the results of tests on small pieces cut from 9 trees growing at an elevation of 3,600 feet, near Weed, Cal. All portions of the tree, both sap and heart, were represented, and the results given are averages of all tests made. The results of similar tests on longleaf pine, Douglas fir, and the more important associated species of incense cedar are given for comparison. Though much weaker than longleaf pine or Douglas fir, incense cedar compares favorably with many other species.

[1] The data on incense cedar are the results of tests conducted at the Forest Service Laboratory operated in cooperation with the University of Washington, Seattle, by O. P. M. Goss, engineer in forest products, July, 1912.

TABLE 9.—*Results of strength tests on incense cedar and associated species as compared with longleaf pine.*

Species.[1]	Specific gravity (based on volume when green).	Bending.				Maximum crushing strength (parallel to grain).	
		Modulus of rupture.		Modulus of elasticity.			
		Pounds per square inch.	Per cent.	Thousands of pounds per square inch.	Per cent.	Pounds per square inch.	Per cent.
Longleaf pine[2] (*Pinus palustris*)	0.528	9,070	100.0	1,540	100.0	4,400	100.0
Douglas fir (*Pseudotsuga taxifolia*)	.418	8,280	91.4	1,597	103.7	4,030	91.7
Incense cedar (*Libocedrus decurrens*)	.363	6,040	66.6	754	48.9	3,030	68.9
White fir (*Abies concolor*)	.350	5,970	65.8	1,131	73.4	2,800	63.6
Sugar pine (*Pinus lambertiana*)	.360	5,270	58.1	966	62.7	2,600	59.1
Western yellow pine (*Pinus ponderosa*)	.377	5,180	57.1	1,111	72.1	2,400	55.0

[1] Tests made on green specimens 2 by 2 inches and free from all defects.
[2] The data on longleaf pine and Douglas fir are from Forest Service Bulletin No. 108; the data on cedar, white fir, sugar pine, and western yellow pine, from Forest Service Circular No. 213.

Tests on strength in relation to moisture, also made on small pieces, showed that thoroughly dry sapwood and heartwood are each 2.50 times as strong as green wood. In these tests the sapwood proved to be slightly stronger than the heartwood at all stages of seasoning. It was not always possible, however, to take the heart and sap specimens from immediately adjacent sections of the tree, which might explain this slight difference.

The average shrinkage in cross section in the above tests, in passing from the green to the thoroughly dry condition, was 9 per cent for the sapwood and 6 per cent for the heartwood.

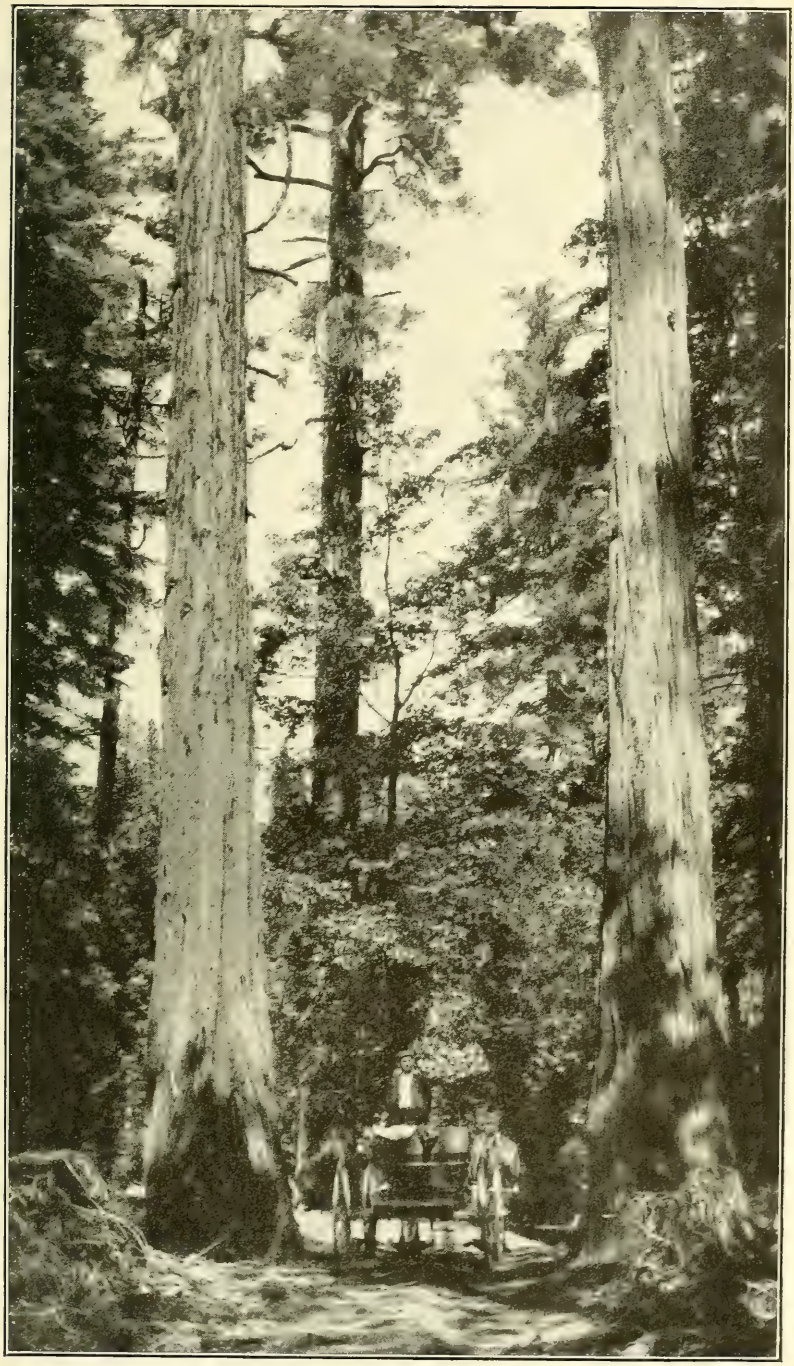
DURABILITY.

Incense cedar is known to be one of the most durable timbers on the Pacific slope. The life of a split heart-cedar fence post is reputed to be from 20 to 30 years, and of rails from 30 to 40, and numerous instances have been cited where they have lasted longer. Sap-cedar posts, on the other hand, are said to last but 5 or 6 years.

THE TREE.

GENERAL DESCRIPTION.

Incense cedar is one of the most characteristic trees of the California forests, its shreddy, deeply furrowed, yellowish-brown or cinnamon colored bark, rapidly tapering bole, and dark-green foliage distinguishing it at once. It resembles somewhat eastern arborvitæ (the white cedar of the north woods) in its flat sprays of scalelike leaves.



F-99393

TYPICAL INCENSE CEDARS, SIERRA NATIONAL FOREST.

F–14071A F–3JAM F–7002A F–4JAM

FOUR STAGES IN THE LIFE OF AN INCENSE CEDAR.

1, Youth; 2, middle age; 3, maturity; 4, old age.

This impression is further strengthened by the appearance of the bark on the younger trees, which is flaky rather than shreddy, and by the crown, which is characteristically conical and compact in early life. The pendulous, blunt-pointed cones,[1] however, are unlike those of any other genus, and serve as a ready means of indentification.

As stated, the tree in early life has a compact, sharply conical crown reaching nearly to the ground. The stem is single and erect, tapering more or less sharply to a slender, gracefully flexible tip. The bark on seedlings is usually smooth and dark green or brown, but in the sapling and pole stage it becomes flaky, more or less tinged with red, and shows a lighter yellowish underbark where it has scaled off. In middle life the tree loses somewhat its conical form of crown, although usually retaining it at the top throughout the period of height growth, unless damaged or badly suppressed. The bark, too, at this stage becomes shreddy and takes on the characteristic yellowish-brown color peculiar to this species, or in some localities a decidedly reddish tinge, which it retains throughout its life. At maturity the tree loses most of its symmetry of form, becomes buttressed, swell-butted, and flat-topped. At this period, too, the crown is usually more or less open and irregular, consisting of a few large scraggly limbs, often deformed by mistletoe and witches' brooms—a condition typical of incense cedar in virgin stands.

SIZE.

Incense cedar varies greatly in size. At maturity, under ordinary conditions, it may be said to average from 75 to 110 feet in height and from 30 to 40 inches in diameter breasthigh. Much larger trees, however, frequently occur. The largest of which there is any record is located near Morgan Springs, Tehama County, Cal., and measures 96 inches in diameter at breastheight, 120 feet in height, and contains approximately 9,700 board feet. Trees 150 feet in height occur in several localities throughout the Sierras, and in Tuolumne County a tree 186 feet high was cut recently. Under less favorable conditions for growth, average diameters and heights, particularly heights, are appreciably less. Thus, in the coast ranges and in southern California cedars from 60 to 80 feet high are the rule, though in the Sierras trees from 100 to 125 are not unusual. At high elevations and on poor sites generally the trees are smaller and scrubbier. On good sites at moderate elevations they make their best growth. Table 10 gives, for several localities, the average merchantable length of trees by diameters, the average number of logs, the maximum and minimum heights, and the average top diameters to which the trees can be cut.

[1] Described fully on p. 17.

TABLE 10.—*Relative diameter, heights, and merchantable lengths of incense cedar; basis, 1,089*[1] *trees.*

[CURVED.]

Diameter at breast-height (outside bark).	Relative total height in different localities.			Minimum height.	Maximum height.	Average.				
	Stanislaus National Forest.	Plumas National Forest.	Sequoia National Forest.			Total height.	Merchantable length.	Number of 16-foot logs.	Average top diameter inside bark.	Basis number of trees.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Inches.*	
8	22	29	.....	14	41	24	.....	.....	.....	.....
10	30	39	.....	19	54	33	8	0.5	6	.....
12	38	48	.....	23	64	41	14	.5	6	.....
14	45	56	.....	28	74	49	23	1.0	7	.....
16	52	64	.....	32	84	54	29	1.5	8	.....
18	58	70	.....	35	93	62	34	2.0	9	11
20	65	76	.....	40	101	69	40	2.0	9	20
22	71	82	.....	44	108	75	45	2.5	9	37
24	77	86	68	48	114	81	50	3.0	9	43
26	83	90	73	51	122	86	55	3.0	9	44
28	88	93	78	55	128	91	60	3.5	9	67
30	94	95	82	58	133	95	64	4.0	10	87
32	100	97	86	61	138	99	70	4.0	10	96
34	105	98	90	65	143	103	74	4.5	10	84
36	110	100	93	68	147	107	78	4.5	10	104
38	114	101	96	71	151	111	82	5.0	10	102
40	117	102	99	74	154	114	86	5.0	10	63
42	120	104	101	76	158	117	90	5.5	10	67
44	123	106	104	79	162	120	93	5.5	10	76
46	124	108	105	82	165	123	96	6.0	10	58
48	126	110	107	85	168	125	98	6.0	10	34
50	127	112	109	87	171	127	101	6.0	10	33
52	129	.....	110	90	174	129	104	6.5	10	21
54	130	.....	.....	92	176	131	106	6.5	10	8
56	131	.....	.....	94	177	133	109	6.5	10	12
58	132	.....	.....	97	179	134	111	6.5	11	8
60	133	.....	.....	100	180	136	114	7.0	11	9
62	.....	.....	.....	102	181	137	116	7.0	11	2
64	.....	.....	.....	104	182	139	118	7.0	11	2
66	190	285	29	107	183	141	120	7.5	11	1

[1] The difference between this figure and the total number of measurements given as a basis in the different localities is due to the inclusion of additional measurements from other localities in deriving the mean.

LONGEVITY.

Like most of the related species, incense cedar is a long-lived tree. A few records of very large trees have been obtained, and trees from 300 to 500 years old are not unusual. The oldest observed was 542 years old at the stump and measured approximately 51.2 inches in diameter at breastheight. It is probable, therefore, that where it is undisturbed it reaches an age of from 800 to 1,000 years.

FORM.

Incense cedar is characteristically short-bodied and rapid-tapering, a feature which is accentuated as the tree approaches maturity by a tendency to become buttressed and swell butted. This characteristic is further exaggerated by the extreme thickness of the bark on the lower portion of the bole, from 6 to 8 inches being not uncommon in old trees. The relative form of the bole at different ages is shown

in figure 1 and its peculiar habit of buttressing is illustrated in figure 2.

In computing age and volume from stump measurements it is necessary, because of the extreme butt taper of the species, to reduce stump measurements to the relative diameters at some fixed point for the sake of comparison. Table 11, prepared for this purpose, gives in terms of inches and tenths of inches the taper from various stump heights to diameter breasthigh, or 4½ feet above the ground, the standard point of measurement.

TABLE 11.—*Taper in diameter outside of bark from stump height to breast-height; basis, 101 trees (Plumas National Forest, 1912).*

[CURVED.]

Stump height.	Diameter at breastheight.								
	18	20	22	24	28	32	36	40	48
	Taper.								
Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1.0	4.0	4.4	5.0	5.7	6.7	7.4	8.1	8.7	9.9
1.2	3.7	4.1	4.6	5.2	6.0	6.6	7.2	7.7	8.6
1.4	3.4	3.8	4.2	4.7	5.3	5.9	6.3	6.8	7.5
1.6	3.2	3.5	3.9	4.2	4.8	5.2	5.6	6.0	6.6
1.8	2.9	3.2	3.5	3.8	4.3	4.7	5.0	5.3	5.8
2.0	2.7	2.9	3.2	3.4	3.8	4.2	4.4	4.7	5.1
2.2	2.4	2.7	2.9	3.1	3.4	3.8	4.0	4.3	4.6
2.4	2.2	2.4	2.6	2.8	3.1	3.4	3.6	3.8	4.1
2.6	2.0	2.1	2.3	2.5	2.7	3.0	3.2	3.4	3.7
2.8	1.7	1.9	2.0	2.2	2.4	2.6	2.8	3.0	3.3
3.0	1.5	1.6	1.8	1.9	2.1	2.3	2.5	2.6	2.9
3.2	1.2	1.4	1.5	1.6	1.8	2.0	2.1	2.3	2.5
3.4	1.0	1.1	1.2	1.3	1.5	1.7	1.8	1.9	2.1
3.6	.8	.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7
3.8	.6	.6	.7	.8	1.0	1.1	1.2	1.2	1.3
4.0	.4	.4	.5	.6	.7	.8	.8	.9	.9
4.2	.2	.2	.3	.3	.4	.5	.5	.5	.5

ROOT SYSTEM.

Incense cedar is decidedly windfirm, and few cases of uprooted trees are to be found. In general, the root system is fairly wide spreading and composed of a number of large, stocky, many-branched laterals with numerous short, small, descending offshoots, forming a compact, intricately tangled mass immediately around the base of the tree. The tree does not develop a taproot beyond the early stages, although a pronounced taproot is characteristic of the seedlings, as in most conifers. Incense cedar stands root pruning better than most species and develops numerous laterals, which makes it an easy tree to handle in the nursery.

FOLIAGE AND BRANCHING.

The foliage of incense cedar is evergreen and consists of small, pointed, scalelike leaves, which adhere closely to the slender branch-

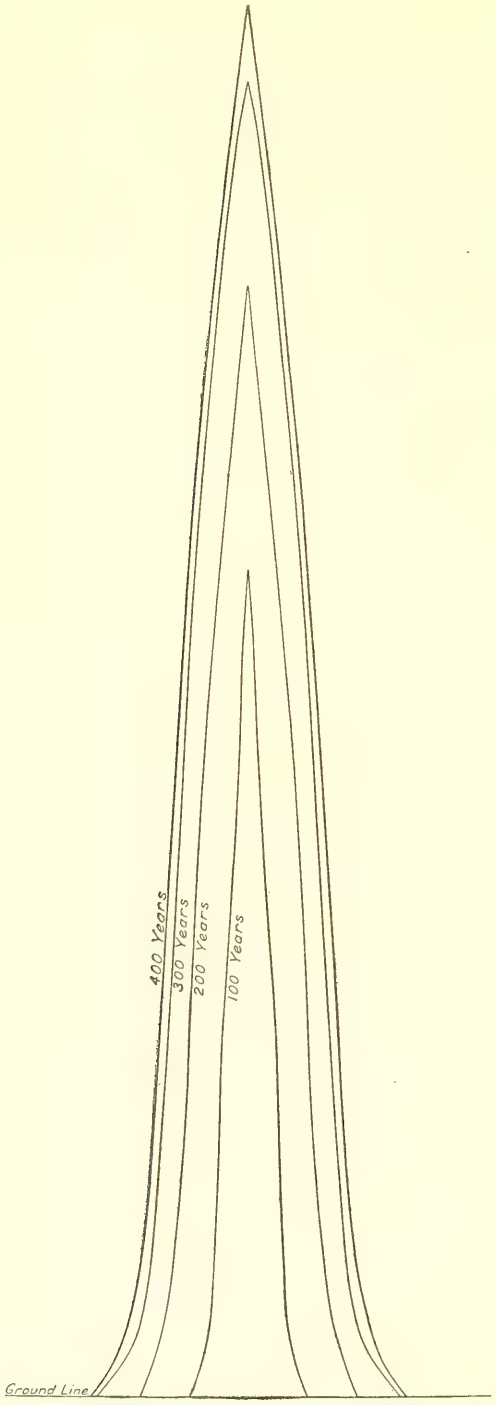


FIG. 1.—Relative form of the bole of incense cedar at various ages.

lets and remain on the tree from 3 to 5 years. The leaves are opposite and four-ranked like those of other species, which are related but are characterized by their long bases, which extend from one-eighth to one-half inch along the branch. They are also keeled, and each is provided with a small resin gland, which accounts for the pungent aromatic odor so noticeable when the leaf is bruised. The younger branchlets have the appearance of being jointed, as two pairs of leaves occur together, at right angles to each other, and overlap slightly the four leaves above.

In the seedling stage incense cedar is characterized by three kinds of leaves (Pl. III), which serve to distinguish it at once from its common associates. The first to appear are the two seed leaves, which measure from 1 to $1\frac{1}{4}$ inches long by one-eighth inch broad. These are followed shortly by one or more branches bearing awl-shaped transitional leaves, which grade off eventually into the normal scalelike foliage. On thrifty, fast-growing seedlings normal leaves are produced the first year. On slower-growing seedlings they do not appear

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FOUR STAGES IN THE DEVELOPMENT OF AN INCENSE CEDAR SEEDLING, SHOWING THE THREE KINDS OF LEAVES—SEED LEAVES, INTERMEDIATE LEAVES, AND TRUE LEAVES.

until the second season. With the appearance of the true leaves the fanlike arrangement of the sprays is first apparent, the seedlings usually developing in one plane for several years.

The branchlets occur alternately, and in one plane, forming an open fan-shaped spray, the smaller side branches of which are often shed about the second year, as is the case with arborvitæ and related species.

The main branches on younger trees are slender and taper gradually, the lower limbs slightly drooping but with upturned tips. Higher up they are more erect, especially as they approach the top. In old age the limbs become thick and angular, tapering rapidly and turning up sharply at the ends, assuming a more or less candelabralike formation. This is particularly true of trees grown on poor sites.

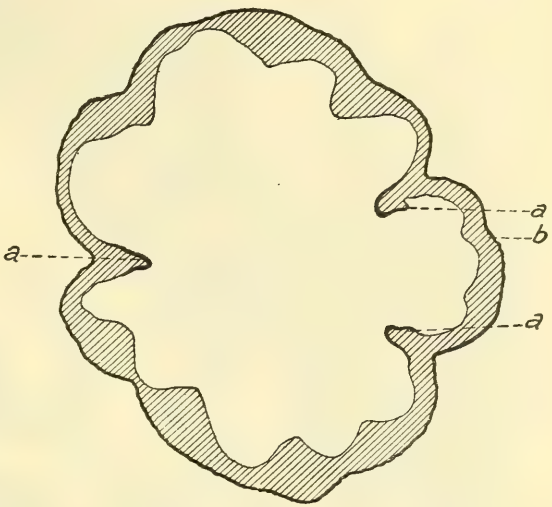

FIG. 2.—Cross section of a mature incense cedar (taken 42 inches above the ground). *a*, old fire scars; *b*, bark.

FLOWERS, FRUIT, AND SEED.

Incense cedar has male and female flowers, which are borne singly at the tips of the twigs of the previous season, usually on separate trees, but occasionally on the same tree and even the same branch. The male or pollen-bearing flowers appear in January as small oblong conelike bodies about one-fourth inch long, and are conspicuous for their golden-yellow color, which often tinges the whole tree during the winter and early spring. The cones or female flowers, at first dark green in color, are usually not noticable until somewhat later. In the summer and fall, however, they turn a yellowish brown and in good seed years are conspicuous by their abundance. Trees standing in the open, even though small, are particularly noticable in this respect, the entire crown frequently being covered with cones. In the fall the cones turn to a russet brown, maturing about September. By October they open and the seeds are distributed, the cones remaining on the trees until the following spring or summer.

The cones are pendulous and from three-fourths inch to 1½ inches long by from one-fourth to five-sixteenths inch in diameter at the thickest part. They are subglobose in form, tapering to a rather

FIG. 3.—Libocedrus decurrens. *a*, male flowers; *b*, fruiting branch; *c*, seed.

elongated blunt point, and consist morphologically of three pairs of scales (practically only two, the two inner pairs being united), one pair of which bear fertile seed.

The seeds, two of which are borne normally at the base of each of the two seed-bearing scales, are small, light brown, and attached to a comparatively large wing measuring from three-eighths to one-half inch in length and from three-sixteenths to one-fourth inch in breadth. The lightness of the seeds, which weigh about 16,000 to the pound, and their relatively large wings adapt them to wide distribution by the wind. The wings are provided with glands containing a clear, red, pungently odorous resin which renders the seed more or less undesirable to rodents. This and the abundance and small size of the seed doubtless do much to insure the perpetuation of the species.

Incense cedar produces more or less seed annually, but good crops are not general oftener than once every three years. Thus, from the records available, we find that in 1906, 1909, 1912, and 1915 the seed crop was good, except in a few localities; whereas in the intervening years either little seed was produced or it was abundant only locally.

REPRODUCTION.

Incense cedar reproduces readily, and in good seed years abundantly. Tests on the seed, however, show a germination of only from 20 to 40 per cent. The seed is distributed in the fall and germinates early in the spring. Its ability to germinate in vegetable as well as mineral soil is advantageous in enabling it to get a foothold in deep litter, bear clover, and similar ground cover, where other species seem unable to start. It is even found growing in old stumps and rotten logs, where it often reaches a considerable size before securing a foothold in the mineral soil. Its long, rapidly growing taproot doubtless aids it a good deal in doing this and does much to insure its survival during the first few years of its life.

Incense cedar ordinarily does not reproduce in the open or in dense shade, seeming to prefer the half light of a high forest or the yellow pine and black oak cover of the upper foothill zone. In early life it is exceedingly tolerant of shade, but requires more light for its full development as it grows older. Consequently, though it survives under dense shade, it is unable to compete with the faster growing pines or the more tolerant firs with which it is associated.

Drought is undoubtedly the seedlings' greatest enemy. The long dry season, extending in normal years from June 1 to October 15, causes many to succumb. In localities where actual counts have been made this loss has been found to amount to as much as 90 per cent, and in dry years it is practically complete.

A good seed year followed by a favorable season means an abundance of reproduction; in other years there is practically none. It is

not uncommon, therefore, to find reproduction occurring in even-aged stands separated by an interval of several years from trees older and younger.

RANGE.

GEOGRAPHICAL.

Incense cedar, next to western yellow pine, adapts itself to a wider variety of conditions than any other tree native to California. It is found growing under almost every condition, and apparently is limited in distribution only by extreme drought, excessive humidity, and the conditions prevailing at high elevations. Its range is from northern Oregon to northern Mexico and from the eastern border of the fog belt in northern California nearly to the limits of commercial tree growth in western Nevada. Its northern limits are irregular, reaching as far north as Breitenbush Creek, on the west side of the Cascades, and to the foothills surrounding Mount Hood on the east side. It also is found on the Rogue-Umpqua divide in eastern Oregon, whence it extends south throughout the Siskiyous into northern California. In California it ranges between the foothills and the subalpine zones on both sides of the Sierras to the Kern River Valley and throughout the coast ranges at increasing elevations into northern Mexico and Lower California, where it finally disappears.

ALTITUDINAL.

East of the Cascades in northern Oregon the tree is found between altitudes of 2,000 and 3,000 feet, and in the southern part of the State between about 4,000 and 5,000 feet; on the west side of the Cascades it is abundant between 1,500 and 3,000 feet, and even higher in the warmer situations. In the coast ranges of California it occasionally goes as low as 1,100 feet, owing to heavier precipitation and an abundance of atmospheric moisture; but the bulk of it is found between 3,000 and 5,000 feet. In the mountains of northern California it grows between 2,500 and 6,000 feet, occasionally reaching as low as 1,000 feet where conditions are particularly favorable. It attains its best growth, however, between 3,000 and 6,000 feet. In the southern Sierras it is seldom found below 3,500 feet, and extends up to 7,000 or 7,500 feet, doing best between 4,000 and 6,800 feet. On the east slope, in extreme eastern California and western Nevada, its range is limited to the Warner Mountains and the northern and central Sierras, where it is confined between the 5,000 and 7,000 foot elevations. In the coast ranges of southern California and northern Mexico it grows still higher, the extreme aridity fixing its lower limit at about 4,000 feet and forcing it up as high as 9,000 or 9,500 feet at its southern limits.

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FIG. 4.—Range of incense cedar.

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A gradual increase in elevation from north to south is apparent, ranging from between 1,100 and 5,000 feet at its northern limits to between 4,000 and 9,000 feet at its southern. Similarly a rise is noticeable from west to east, the limit in the coast ranges being 1,100 and 5,000 feet, on the west slope of the Sierras 3,000 and 7,000 feet, and in western Nevada 5,800 and 7,000 feet.

SILVICAL REQUIREMENTS.

MOISTURE.

The minimum water requirement of incense cedar is low compared with other commercial timbers, as is shown by its frequent occurrence on dry, exposed ridges and at the extreme lower limits of commercial tree growth. It does best, however, where the supply of soil moisture is fairly abundant. In its drought-resisting qualities it is second only to western yellow pine among the commercially important species of its range; but extreme drought serves effectually to shut it out and, more than any other factor, prevents it from spreading to lower elevations. Excessive moisture, on the other hand, is equally effective in limiting its range. Hence we do not find it encroaching on wet mountain meadows or extending any great distance into the regions of excessive precipitation of the Pacific Northwest.

Soil moisture and humidity complement each other to a certain extent, it being possible for an abundance of one to make up partially for a lack of the other. Where soil moisture is sufficiently abundant, however, incense cedar will grow in an almost arid climate, showing that no great amount of humidity is essential.

LIGHT.

Incense cedar is a shade-enduring tree and reaches its best development in fairly dense stands. It is surpassed in tolerance only by white fir and possibly, in northern California and southern Oregon, by Douglas fir. The reluctance with which it sheds its lower limbs is an indication of this extreme tolerance. To kill out incense cedar by shading is almost impossible, though, of course, too much shade hinders growth, and an abundance of light, if other conditions are favorable, helps it.

TEMPERATURE.

Temperature is undoubtedly an important factor in the distribution of incense cedar, particularly in limiting its range at the higher elevations. The extreme cold, combined with the short growing season, is probably responsible more than any other factor for ex-

cluding this tree from the higher mountains. To a limited extent, heat may have some influence in fixing its lower limits. However, in view of the continued high temperatures which the tree is known to endure, it is doubtful whether heat has this effect, except as it reduces an already meager supply of moisture by causing excessive evaporation.

SOIL.

Of all the various factors affecting the occurrence of incense cedar, soil is probably the least important. The best proof of its adaptability in this respect is the fact that throughout its range it is found growing on soils of every description, bowlder wash and wet adobe excepted.

GROWTH.

Incense cedar is naturally a slow-growing tree. Under favorable conditions, however, its growth is fairly rapid, although it can not compete successfully with its more aggressive associates, sugar pine, yellow pine, and white fir.

HEIGHT GROWTH.

Table 12, which is based on stem analysis of 1,000 seedlings, shows the extremely slow growth of this species during the seedling stage under the average conditions prevailing in virgin stands.

TABLE 12.—*Incense cedar, seedling growth (age–height); basis, 1,000 seedlings.*

[CURVED.]

Age.	Height in feet.			Age.	Height in feet.		
	Average heights of all seedlings below the mean.	Mean. height.	Average heights of all seedlings above the mean.		Average heights of all seedlings below the mean.	Mean. height.	Average heights of all seedlings above the mean.
Years.				*Years.*			
5	0.2	0.5	1.0	25	1.7	2.7	5.1
10	.5	1.1	2.0	30	2.1	3.3	.....
15	.9	1.6	2.9	35	2.6	3.9	.....
20	1.3	2.2	3.9				

Under ordinary conditions, suppression is doubtless responsible to a large extent for this extremely slow growth, since reproduction, as a rule, occurs only in small openings or under the half light of a high forest, where the encouragement for rapid growth is small. In the larger openings and on cut-over lands, where light is abundant seedlings shoot up rapidly after they have once become thoroughly established. In fact, in all cases except those of extreme

suppression the seedling stage is followed by a period of more or less rapid height growth.

Incense cedar, under ordinary conditions, makes its fastest height growth between the ages of 40 and 150 years, growing most rapidly between the fiftieth and seventy-fifth years. When the maximum has once been reached, however, height growth falls off rapidly until at about 100 years the periodic or current annual growth falls below the mean annual growth. Beyond 150 years, growth in height is merely nominal. While height growth varies in amount in different localities, the above statements held true in every case studied, except one on the Plumas National Forest. Here, while the rate of height growth at no time equaled the maximum in other localities, the period of height growth was prolonged considerably, continuing at a fair rate up to 300 years of age.

TABLE 13.—*Height growth of incense cedar.*

[CURVED.]

Age.	Locality.				Average of all above the mean.	Average of all below the mean.	Mean.	
	Eldorado.	Plumas.		Stanislaus.			Total height.	Basis number of measurements.
		T. 24 N., R. 5 E.	T. 24 N., R. 10 E.					
	Total height (feet).							
Years.							*Feet.*[1]	
60	52				58	12	23	46
80	67				73	29	49	
100	78	52	61		84	43	65	
120	86	63	70		92	53	75	177
140	92	74	77	95	98	60	82	
160	97	83	82	100	102	67	86	
180	100	90	86	104	105	71	90	
200	104	96	89	108	108	76	93	
220	106	101	91	112	111	79	96	196
240	109	106	93	116	113.5	82	98	
260	112	109.5	95	119	116	85	101	
280	114	113	96.5	122	118	88	103	
300	116	116	98	124	119.5	89.5	105	
320	118	119	99	127	121	91	106	96
340	120	121	100	129	122.5	92.5	108	
360		123	101		124	94	109	
380		125	102		125.5	95.5	110	
400		126	103		127	97	111	
Basis number of measurements	60	90	319	34				[2] 515

[1] Figures rounded off to the nearest foot.

[2] The difference between this figure and the total number of measurements indicated for the different localities is due to the inclusion of additional measurements, more or less scattered, from other localities in deriving the mean.

DIAMETER GROWTH.

Rapid diameter growth is confined largely to early life, although under favorable circumstances it continues for a considerably longer period than rapid height growth. Under ordinary conditions it

continues for about 200 years, after which it drops off, slowly at first, but more and more rapidly as old age approaches. The period of maximum diameter growth follows closely the period of maximum height growth, beginning about the time height growth culminates. The maximum rate is attained shortly after the periodic annual height growth falls below the mean.

Table 14 gives, for the sake of comparison, the average diameters breasthigh at different ages for trees growing in different localities. Considerable difference will be noted in the growth rate prevailing in the localities represented, but it also will be found that the period of rapid growth corresponds closely in every case.

TABLE 14.—*Diameter growth of incense cedar outside bark at breastheight.*

[CURVED.]

Age.	Locality.								Average.
	Eldorado National Forest.	Plumas National Forest (T. 24 N., R. 5 E.).	Shasta National Forest.	Modoc National Forest.	Kern National Forest.	Tahoe National Forest.	Plumas National Forest (T. 24 N., R. 10 E.).	Klamath National Forest.	
	Diameter breasthigh outside bark.								
Years.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
30	1.6	0.1	1.4	0.4	1.6	1.1	1.2	1.0	1.3
40	3.8	2.1	3.4	1.8	3.8	2.5	3.8	2.3	3.2
60	8.7	5.4	7.2	5.2	6.3	5.3	5.7	5.0	6.4
80	13.9	8.7	11.4	9.0	12.9	8.1	8.9	8.0	9.8
100	19.2	12.6	16.0	12.8	17.2	11.1	12.2	10.7	13.6
120	23.6	17.4	20.0	16.6	20.9	14.1	15.5	13.5	17.8
140	27.0	23.2	23.4	20.1	24.0	17.0	18.4	16.2	21.3
160	29.7	25.4	26.2	23.0	26.7	19.7	20.8	18.9	23.6
180	31.8	27.8	28.4	25.5	28.9	22.0	22.5	20.3	25.7
200	33.5	30.2	30.6	28.0	30.8	24.0	24.0	23.0	27.8
220	35.2	32.5	32.6	30.3	32.4	25.8	25.3	24.4	29.8
240	37.0	34.6	34.6	32.6	33.8	27.5	26.6	25.7	31.7
260	38.7	36.6	36.6	34.8	35.0	29.1	27.9	27.0	33.6
280	40.4	38.5	38.4	37.0	35.9	30.5	29.9	28.3	35.4
300	.....	40.1	40.0	.....	36.9	31.9	30.2	29.6	36.9
320	.....	41.7	41.4	.....	37.7	33.1	31.1	31.0	38.2
340	.....	43.1	42.5	.....	38.6	34.3	31.9	32.3	39.2
360	.....	44.4	.....	.....	39.4	35.3	32.5	33.5	40.1
380	.....	45.3	.....	.....	.....	.....	33.1	.....	40.9
400	.....	46.0	.....	.....	.....	.....	33.7	.....	41.6
Basis number of stump analysis	27	100	37	26	23	20	101	26	360

VOLUME GROWTH.

The cubic contents of the entire stem and the board-foot contents of the merchantable portion of trees of different ages grown in virgin stands are given in Table 15, together with the average heights and diameters on which these volumes are based.[1]

[1] Complete volume tables will be found in the Appendix.

TABLE 15.—*Growth in diameter, height, and volume of incense cedar.*

[CURVED.]

Age.	Average diameter outside bark at breast-height.	Average total height.	Volume.[1]	
			Cubic feet outside bark.	Board feet (Scribner Dec. C).
Years.	*Inches.*	*Feet.*		
100	13.6	65.0	32	70
110	15.8	70.0	44	100
120	17.8	75.0	56	140
130	19.9	79.0	68	190
140	21.3	82.0	80	230
150	22.5	84.0	92	270
160	23.6	86.5	103	310
170	24.7	88.0	114	340
180	25.7	90.0	126	390
190	26.8	91.5	138	440
200	27.8	93.0	150	490
210	28.8	94.5	163	540
220	29.8	95.5	176	600
230	30.8	97.0	190	670
240	31.7	98.5	204	720
250	32.7	99.5	219	790
260	33.6	100.5	234	850
270	34.5	101.5	250	900
280	35.4	103.0	264	970
290	36.2	104.0	278	1,030
300	36.9	104.5	290	1,090
310	37.6	105.5	302	1,160
320	38.2	106.5	313	1,200
330	38.7	107.0	323	1,240
340	39.2	107.7	333	1,290
350	39.7	108.5	342	1,340
360	40.1	109.0	350	1,380
370	40.5	109.5	359	1,410
380	40.9	110.0	367	1,440
390	41.3	111.0	375	1,480
400	41.6	111.5	383	1,510
Basis...	[2] 360	[3] 515	.....	.....

[1] Volumes given are based on volume-table values for corresponding heights and diameters.
[2] Stump analyses.
[3] Measurements.

The period of most rapid volume growth occurs later in life than the period of either rapid height or rapid diameter growth. The maximum periodic growth is reached at an age of about 275 years, after which increment falls off rapidly, dropping below the mean annual increment at about 345 years. The mean annual increment, however, increases gradually until an age of about 300 years is reached, after which it remains fairly constant, declining but slightly in the next 100 years. This, it should be remembered, is true of the growth of individual forest-grown trees only. The growth in volume of stands culminates much earlier and has no direct relation to that of individual trees.

Table 16 shows how incense cedar compares with sugar pine and yellow pine in rate of growth and why it can not compete successfully with these species in mixed stands.

TABLE 16.—*Comparative rate of growth of sugar pine, yellow pine, and incense cedar.*

Age.	Sugar pine.			Yellow pine.[1]			Incense cedar.		
	Diameter breast-high.	Height.	Volume.	Diameter breast-high.	Height.	Volume.	Diameter breast-high.	Height.	Volume.
Years.	*Inches.*	*Feet.*	*Board feet.*	*Inches.*	*Feet.*	*Board feet.*	*Inches.*	*Feet.*	*Board feet.*
20	0.2	8	.....	2.3	12	.....	.....	.....	.....
40	2.5	23	.....	6.5	29	.....	3.2	.....	.....
60	7.5	45	.....	11.4	57	.....	6.4	23	.....
80	13.0	72	110	16.1	79	210	9.8	49	.....
100	18.1	92	240	20.0	94	360	13.6	65	70
120	22.7	106	490	23.3	104	610	17.8	75	140
140	26.8	118	850	25.8	112	890	21.3	82	230
160	30.5	127	1,290	28.0	118	1,170	23.6	86	310
180	33.9	135	1,760	29.8	123	1,430	25.7	90	390
200	37.0	142	2,250	31.3	127	1,640	27.8	93	490
220	40.0	148	2,830	.....	.....	.....	29.8	96	600
240	42.5	153	3,460	.....	.....	.....	31.7	98	720
260	44.9	158	4,120	.....	.....	.....	33.6	101	850
280	47.2	162	4,840	.....	.....	.....	35.4	103	970
300	49.3	167	5,570	.....	.....	.....	36.9	105	1,090
320	51.4	171	6,020	.....	.....	.....	38.2	106	1,200
340	53.5	174	7,050	.....	.....	.....	39.2	108	1,290
360	55.5	177	7,740	.....	.....	.....	40.1	109	1,380
380	57.3	180	8,380	.....	.....	.....	40.9	110	1,440
400	59.1	183	9,010	.....	.....	.....	41.6	111	1,510

[1] From Forest Service Bulletin 69, "Sugar Pine and Western Yellow Pine in California," by Albert W. Cooper.

GROWTH IN EVEN-AGED STANDS.

Growth in diameter, height, and volume in even-aged stands is, as might be expected, much more rapid than that prevailing in virgin all-aged stands, where competition for light and growing space is keen. As is shown in Table 17, which is based on measurements gathered in Madera, Tuolumne, and Yuba Counties, this difference is considerable. Unfortunately, no mature even-aged stands exist, and only general conclusions can be drawn as to the growth in later life under such conditions. It is evident, however, that incense cedar would make much better growth in even-aged stands than in the all-aged virgin forests.

TABLE 17.—*Average growth of individual trees in even-aged stands; basis, 35 trees.*

[CURVED.]

Age.	Total height.	Diameter breast-high outside bark.	Volume.
Years.	*Feet.*	*Inches.*	*Cubic feet.*
10	5.5	.....	.....
20	15.5	3.1	0.5
30	30.0	6.3	1.3
40	43.5	9.2	4.2
50	53.0	11.7	9.9
60	60.0	13.6	17.2
70	64.0	14.9	26.0
80	67.0	15.9	31.6

GROWTH AFTER CUTTING.

Examinations of recent cuttings on lands culled over 30 or 40 years ago indicate that the ability of incense cedar to recover from suppression is slight, once the period of rapid diameter and height growth is passed. Up to the present, however, observations have been too limited to justify definite conclusions, and further study will be necessary before its possibilities in this respect can be determined conclusively.

FOREST TYPES AND ASSOCIATED SPECIES.

Incense cedar is confined to two main forest types—the semiarid or western yellow-pine type and the middle-slope or mixed-conifer type. The first, in which yellow pine or Jeffrey pine predominates and incense cedar is represented sparingly, forms a narrow belt in the upper foothill zone, on the west slope of the Sierras and the east slope of the northern coast ranges, between the digger pine and the chaparral of the foothills and the mixed conifer stands of the timber belt. This type also is found in a modified form on the lava beds in northeastern California, where it covers large areas, and on the east slopes of the Sierras, where it again forms a border along the lower edge of the commercial timber zone.

Most of the incense cedar, however, is found in the mixed conifer forests of the middle slopes. This type is of varying composition, being made up of western yellow pine, Jeffrey pine, sugar pine, white fir, Douglas fir, and incense cedar in all proportions. In the southern Sierras Douglas fir is absent; in central and northern California it appears in constantly increasing proportions toward the north until, in the Siskiyous, it is the predominating species. From lower to higher elevations, too, the composition varies, the pines predominating at first, only to give way to the firs higher up. A variation of the mixed-conifer type of the middle slope occurs on the east slope of the Sierras, where Jeffrey pine and white fir predominate and incense cedar occurs scatteringly.

Incense cedar is sometimes found in the lower subalpine zone mixed with white fir, red or Shasta fir, lodgepole pine, and even western white pine. At lower elevations, where lodgepole pine occurs in the vicinity of mountain meadows, incense cedar grows near by on the drier portions of the site, but seldom mixes with it.

At its extreme lower limits, where it is confined to ravines and watercourses, incense cedar occurs occasionally with yew and California nutmeg; and in the coast ranges it occurs with a number of broadleafed trees, among which are the broadleafed maple, alders, willows, dogwood, madroña, chinquapin, and tanbark oak.

Throughout the upper foothill belt on the west slope of the Sierras, California black oak is a particularly common associate of

incense cedar, being found throughout the yellow-pine and lower mixed-conifer zones. Other oaks also are found with it, although not so extensively.

Bigtree or mountain redwood (*Sequoia washingtoniana*) also occurs within the range of incense cedar, and is associated more or less intimately with it wherever found.

In southern California incense cedar associates most frequently with western yellow, Jeffrey, and sugar pine. Here at the upper limits of its range it also mixes with white fir and occasionally with lodgepole or limber pine, while below the commercial timber belt it is found growing with big-cone spruce, piñon, coulter pine, and western juniper.

STAND.

Owing to the scattered occurrence of incense cedar, figures as to stand and yield have little general application, since the widest variations frequently occur in the same locality and the species seldom, if ever, predominates in the stand. As an example, however, of actual conditions, the average stand of cedar in the mixed-conifer type on the Plumas National Forest, based on an intensive reconnaissance of 2,200 acres, is given in Table 18.

TABLE 18.—*Average stand of incense cedar per acre, mixed-conifer type, Plumas National Forest; average of 2,200 acres, from reconnaissance data.*

Diameter breasthigh (inches).	Number of trees per acre, incense cedar.	Per cent of total number of incense cedars in each diameter class.	Per cent of incense cedar in the stand by diameter classes based on number of trees.
12	0.36	7.5	21.1
14	.32	6.6	20.0
16	.36	7.5	23.3
18	.39	8.2	24.2
20	.48	10.5	24.6
22	.45	9.3	27.2
24	.45	9.3	23.9
26	.37	7.8	21.9
28	.26	5.5	22.8
30	.29	6.1	23.5
32	.35	7.2	27.5
34	.17	3.4	20.6
36	.17	3.4	27.3
38	.11	2.2	19.5
40	.01	1.5	16.5
42	.11	2.2	33.1
44	.03	.6	13.1
46	.06	1.2	30.1
48	.01	.0	5.0
50	.....	.....	.....
52	.01	.....	12.0
Total	4.82	100.0	23.1

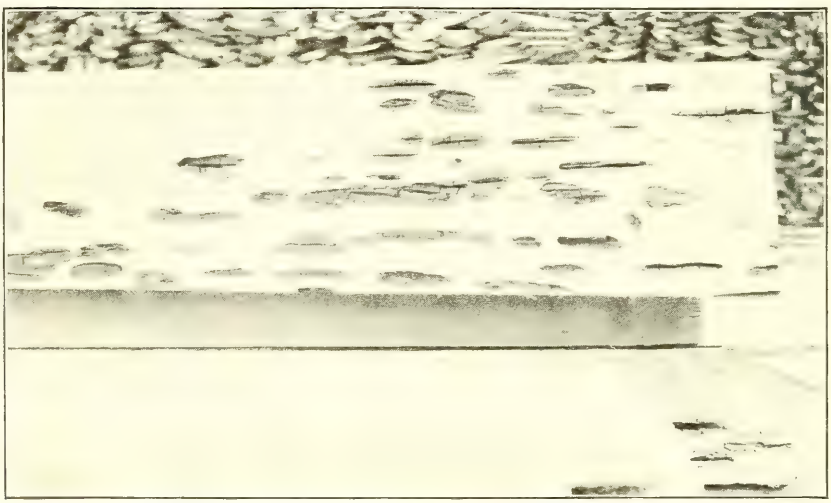
Expressed in terms of volume, the average stand of incense cedar was 2,329 feet, board measure, per acre or about 14 per cent of the total volume.

F-99523

INCENSE CEDAR (X) GROWING IN A TYPICAL OPEN STAND OF WESTERN YELLOW PINE, SUGAR PINE, AND FIR.

F-1JAM

FIG. 1.—BUTT OF A CULL INCENSE CEDAR LOG, SHOWING TYPICAL DRY-ROT.



F-2JAM

FIG. 2.—CULL PLANK OF INCENSE CEDAR, SHOWING THE RESULT OF DRY-ROT.

ENEMIES.

DISEASE.[1]

Incense cedar is subject to few diseases, but three of these are very common. They are caused by a mistletoe (*Phoradendron juniperinum libocedri*), a rust fungus (*Gymnosporangium blasdaleanum*), and the dry-rot fungus (*Polyporus amarus*). The only serious damage to merchantable trees, however, is due to the latter.

Polyporus amarus attacks the heartwood of mature living trees only, trees below the age of 140 years being more or less immune. Thrifty growing trees in damp, rich soils seem to be less affected than slow-growing ones on dry, poor sites; and trees with large wounds are far more likely to be pecky than intact ones.

The large annual fruiting bodies (sporophores or conchs) of *Polyporous amarus* invariably grow out of branch holes or pin knots, never through the bark. The mature conch has the shape of a bell cut lengthwise in halves. The upper side is light tan in color, the under side a brilliant yellow, turning brown with age. Spores are formed in enormous numbers and are carried by air currents to other trees. They germinates only when they land on a wound or opening leading to the heartwood. Thus fire scars and branch stubs very often offer them an easy entrance. The fungus attacks the heartwood, honeycombing it with cavities from one-quarter inch to an inch in diameter by from an inch to several feet in length. These cavities are filled with a dry, brown, charcoal-like substance which characterizes this defect and gives it its name of "dry" or "brown" rot. The wood between the cavities is usually sound.

It is often impossible to detect the presence of dry-rot from the outward appearance of the tree, but there are certain infallible signs by which we can tell that the timber is infected. The presence of a fruiting body of *Polyporus amarus*, of course, indicates beyond a doubt that the fungus is at work in the heartwood. But the fleshy annual fruiting bodies are devoured eagerly by squirrels and the larvæ of a small moth that afterwards burrows through into the dead bark. Later, woodpeckers chop out these larvæ, so that, finally, a cup-shaped depression, pierced with numerous larvæ holes, is formed in the bark where the fruiting body once was. These depressions are a certain sign of decay, and their number and appearance indicate the extent of the dry-rot in the interior of the tree. In general, the decay is more pronounced in the lower part of the tree, since the fungus very commonly starts from fire scars.

Since the entrance of the dry-rot fungus into the heartwood can in a great number of cases be traced to fire scars, fire prevention and

[1] Prepared by Dr. E. P. Meinecke, pathologist, Bureau of Plant Industry.

control is the first step in eliminating the disease. Where possible, also, trees with large wounds, whether from fire or otherwise, should be marked for cutting in preference to sound ones, and no trees with a fruiting body of *Polyporus amarus* or with the cup-shaped depressions described above should be left standing.

FIRE.

Repeated ground fires are responsible for considerable damage throughout the range of incense cedar, and few mature trees are to be found that do not show some evidence of this in burned butts and cat faces. In some regions fire damage has been extreme, practically every tree being hollowed out at the base or felled by repeated fires. The thick bark of this species and its rather fire-resistant foliage offer considerable protection to mature trees; but severe fires, especially where there is an accumulation of débris, do a great deal of damage, since the somewhat resinous bark burns like punk, and a fire once started in it often burns for a long time. Repeated fires eat into the tree, each successive fire enlarging the wound already made and increasing the danger of infection from disease. Incense cedar is, however, persistent, seldom succumbing to fire alone unless completely girdled or so burned out at the base that it falls through lack of mechanical support. Burning stimulates the natural tendency of the tree to buttress, extraordinary growth frequently being made in this way in an attempt to overcome the damage done.

In stands of young cedar damage from fire is usually more severe, owing to the thinner bark and the greater exposure of the crown to the heat of the flames. Although somewhat more fire resistant than the more resinous pines, its power of recovery is less, and it ranks after yellow and sugar pine, owing apparently to a lower fire resistance of the terminal buds. As a consequence, an incense cedar when scorched is usually as severely damaged as appears at first, while pines frequently recover entirely in a year or two, though at first the entire crown apparently has been killed.

The greatest damage by ground fires is to reproduction. No matter how light the fire, the smaller seedlings, growing half buried in the litter, are destroyed, and no future stand can be expected where the practice of light burning is followed or adequate fire protection is not given.

INSECTS.

Incense cedar rarely is killed by insect infestation, except in the seedling and sapling stage. Like the sequoias, mature trees are practically immune from attacks causing death in one season. Mature

trees are, however, sometimes killed by repeated attacks of several species of beetles, and individual trees or small stands of cedar reproduction are often killed by a species of *Phloeosinus*. Trees attacked by this beetle are killed outright in one summer, turning pale yellow by July and generally dying by October 1. To control insects in reproduction, all infested trees should be felled and burned during the fall, winter, or spring months before the beetles have emerged.

When numbers of trees are found dying and there is evidence of primary insect injury the matter should be reported to the Bureau of Entomology with specimens of the insect or its work and request for information on the proper action to be taken.

SNOW, WIND, GRAZING, ETC.

As incense cedar occurs in close stands and more or less protected situations, snow and wind probably would cause comparatively little damage were it not for the brittleness of the tops and branches. As it is, exposed trees invariably show the effects of snow and high winds by irregular one-sided crowns and broken or distorted tops. Considerable damage also is done to young timber when a heavy fall of wet snow is followed by high winds, the brittle branches and tops being frequently snapped off. Throughout its life, however, incense cedar is highly persistent in endeavoring to overcome this handicap by sending up new leaders, a tendency which results in the characteristic pronglike tops so common on this species.

Incense cedar is probably subject to less damage from logging than any of its associated species, the seedlings and smaller saplings being tough, firmly rooted, and able to survive considerable hard usage. For the same reasons and because of the protection offered by the resinous, highly pungent foliage, which renders it less palatable than its associates, it is seldom damaged by sheep and cattle.

MANAGEMENT.

GENERAL POLICY ON NATIONAL FORESTS.

At the time the Forest Service first undertook the administration of the National Forests incense cedar was regarded as a weed tree; and, in early sales of Government timber, efforts were made to eliminate it from the stand by marking it heavily for cutting. Later, as the excellent character of the lumber derived from it when sound became known, this policy was modified and sound thrifty trees were spared when they did not interfere seriously with the development of the more highly valued species. To-day, in view of its increasing value, incense cedar is receiving more consideration and its possibilities are being studied in an effort to determine the methods best adapted to insure its perpetuation and maximum development.

PROBLEM OF MANAGEMENT.

In view of the fact that for many years to come the Forest Service, as well as timber owners in the West generally, will be concerned primarily with the management of virgin forests, it is evident that the immediate problem is the utilization of the present crop of mature and overmature timber and the protection of second-growth stands against loss through fire and disease.

As has already been brought out, most of the merchantable incense cedar to-day consists of mature timber practically at a standstill as regards growth and more or less affected with dry-rot. The logical procedure, therefore, is to cut out as fast as practicable all mature and infected trees, disposing of them at a nominal price if necessary, in order to insure the health and soundness of the remaining stand. Such a policy is now practiced by the Forest Service in sales of Government timber and should be the policy of all private operators who are interested in the future of their holdings. By adequate fire protection and the elimination of all diseased timber as the forested areas are cut over, future stands and the young and thrifty growing stock already established can be prevented to a large extent from falling into the unfortunate condition now prevailing in virgin stands. Fortunately, under normal conditions, natural reproduction of incense cedar is excellent, so that protection from fire and a reasonable amount of care in cutting are all that is necessary to insure a perpetuation of the stand.

Next in importance, from the standpoint of management, is the encouragement of rapid growth and improved form in future stands of this species. Here the opportunity of the forester to overcome the obstacles presented is limited only by the maximum possibilities of the tree and the economic conditions which must be met in order to insure a reasonable return on the investment.

ROTATION.

Preliminary studies by Dr. E. P. Meinecke have shown that on the most favorable sites few trees below the age of 150 years are affected with dry-rot. It is probable, therefore, that with proper sanitation and adequate protection from fire little loss need be feared before this age is reached. This is sufficient time under ordinary conditions for cedar to grow to a diameter of about 2 feet. Under proper silvicultural treatment this size can be increased materially without exceeding the rotation thus established.

While under natural conditions incense cedar does not reach maturity until about the three hundred and forty-fifth year, it reaches merchantability, or a diameter of 28 inches, in about 200 years, and under favorable conditions for growth, such as might be expected to prevail in managed stands, in 150 years. This estimate is con-

servative for managed stands, since it is based entirely on what the tree has done in virgin stands. Though the most satisfactory rotation can not be determined definitely until stands have actually been brought under management, the above gives a working basis that is amply conservative.

SILVICULTURAL TREATMENT.

Incense cedar is naturally such a slow grower that in spite of its wide distribution and ready adaptability to various sites it can never be grown at a profit under any but the most favorable conditions. It would be folly to attempt to do so on sites where conditions are otherwise. It is even a question whether it should not be eliminated from the stand entirely on the sites less adapted to it, in order to favor as far as possible the species which can be counted on to produce an adequate return. Under the most favorable conditions and with proper handling incense cedar probably will yield returns equal to, or greater than, those of its associates because of its value for special uses.

In general, however, the management of incense cedar will have to be subordinated to that of its more important associates, since it is unlikely that the forests in which it occurs will ever be handled with the single purpose of securing the best conditions of growth for it alone, or that it will ever be grown over large areas. The following discussion, therefore, must be considered as outlining the ideal management for incense cedar rather than the one which at present is economically advisable.

Having adopted a rotation, the next question is how best to secure maximum development in the size and quality of the timber to be grown. Will incense cedar do best when grown with other species or when grown alone? Should it be grown in all-aged or in even-aged stands, and what silvicultural system will give the best results—selection cutting, clear cutting and planting, the shelterwood method, or the seed-tree method?

CHARACTER OF STANDS.

Incense cedar is a tree particularly well adapted to growing in mixture with other species. The fact that it is never found in pure stands, as well as its extreme tolerance, indicates this. On the other hand, its slow growth when suppressed and its fairly rapid growth, particularly in early life, when light, especially top light, is abundant, indicates that in even-aged stands the yield will be greater than in stands where all ages are represented and only the dominant trees receive full light. The study of growth in even-aged stands substantiates this conclusion.

SPECIES IN MIXTURE.

All things considered, yellow pine is probably the most desirable tree to grow in combination with incense cedar, for, although its growth is more rapid, its foliage is not so dense as to suppress the cedar materially during the first 75 or 100 years, and in close stands it aids materially in forcing height growth and in shading out the lower limbs, thus insuring a reasonably clear length. Sugar pine, owing to its more open crown, is probably not so well adapted to this purpose as yellow pine, and the firs (both white and Douglas), because of their rapid growth and denser foliage, would tend to suppress the cedar and thus materially retard its growth.

SILVICULTURAL SYSTEMS.

It is probable that some modification of the shelterwood or selection border cutting will give the best results, although to a large extent this will have to be worked out by actual field tests. The considerations leading to this conclusion are: (1) The fact that incense cedar is an abundant seed producer, (2) that reproduction is established readily under a high forest but not so readily under a dense cover or in the open, (3) that in this way stands practically even aged can eventually be secured. Strictly even-aged forests over areas of any considerable extent can of course be secured only by planting, but this is out of the question under present economic conditions. A method of cutting, then, that will insure approximately even-aged stands is desirable.

On areas large enough in extent to be capable of producing a sustained yield sufficient to warrant continuous operations or cuts at frequent intervals, say, every 5 or 10 years, the selection border cutting or a progressive thinning of successive strips would seem to be most advisable. This system allows the gradual opening up of the forest, thus insuring satisfactory stocking and progressively even-aged stands. On small areas, to be cut over only at long intervals or at the end of the rotation, a modification of the shelterwood system, which would provide for an opening up of the stand by the removal of the nurse trees and larger cedars at the time growth ordinarily begins to fall off, probably would give the most satisfactory results. The period of rapid development could thus be prolonged and the establishment of a second crop as an understory assured.

While the silvicultural systems named above are applicable in general, the details necessarily will have to be worked out in each particular case. A feature in favor of these methods, however, is their flexibility, which not only makes possible such modifications as are necessary to meet local conditions, but also such changes as may be necessary to meet variations in the silvicultural condition of the stand or fluctuations of the market.

ARTIFICIAL FORESTATION.

SEED COLLECTING.

GATHERING THE SEED.

The seed of incense cedar matures usually during the latter part of September or the first three weeks of October. The ripe cones may be gathered from the trees and the seed extracted later, or by spreading canvas or blankets beneath the trees and vigorously thrashing the branches the seed may be collected direct.

EXTRACTING AND CLEANING SEED.

Where the cones have been collected from the trees it is necessary to extract the seed artificially. This is usually done by spreading the cones on canvas or blankets in the sun until they open, which requires about three days, and then thrashing out the seed by hand. In stormy weather a drying house and artificial heat are necessary.

It is desirable to remove the wings from the seed, so far as is possible, and this may be accomplished in a measure by rubbing them vigorously between the hands, thus breaking off the greater portion of the wing. As a rule, however, this is not done, the seed simply being separated from the chaff and light nonfertile seed by means of a fanning mill fitted with screens of the proper mesh, or by pouring the seed from one box to another in a current of air.

YIELD AND COST OF SEED COLLECTION.

Incense cedar seed is quoted by various seed dealers on the Pacific coast at from $1.65 to $4 a pound, and seed collected by the Forest Service in the past has cost from $1.50 to $2.25 a pound, according to the conditions under which the collecting was done. As to the yield to be expected, experience has shown that on the average from 2 to 3 pounds of clean seed can be secured from a bushel of cones, while the number of seed per pound averages about 16,000.

STORAGE.

Seed of this species keeps best if placed in bags and stored in a cool, dry, well-ventilated place. Since it is very apt to mold if large quantities are kept in one bag with insufficient ventilation, the bags should not be too large and they should be hung up rather than piled in a compact heap, a precaution which also guards against the depredations of rodents.

NURSERY PRACTICE.

Owing to its relatively low germination per cent (from 20 to 40), it is necessary to sow incense cedar seed comparatively heavily. On

the average, therefore, about 3 pounds is usually sown to each 100 square feet of seed bed, or 1½ pounds to each 100 linear feet of drill.

Under favorable conditions germination usually takes place in about three weeks and is fairly uniform, little if any of the fertile seed lying dormant. The seedling develops fairly rapidly for a conifer, and by the end of the first season is from 2 to 4 inches tall and has a root from 6 to 10 inches long. When 1 year old it usually is transplanted into beds or pots, and when 2 or 3 years old it is set out in the field, having by that time reached a height of from 6 to 10 inches. The cost of raising stock varies widely, but is proportionately less when large quantities are raised. At the Pilgrim Creek nursery on the Shasta National Forest, in 1912, the cost of raising 1-year-old seedlings was $7.63 per 1,000, including overhead charges, and it was estimated that 2-year-old stock one year in the transplant beds had cost approximately $13.35 per 1,000. Adding $2.98, the average cost of preparing for shipment and hauling to the railroad, gives the average cost of stock of this species when it left the nursery as $16.63 per 1,000. At other nurseries where stock has been raised in smaller quantities and transplanted into paper pots instead of transplant beds the cost has run as high as $27.50 per 1,000. There is little question, however, that stock of this species raised in commercial quantities could be produced at a cost considerably below these figures. For ornamental purposes, for which there is a growing demand, incense cedars bring 60 cents apiece when from 6 inches to 1 foot high and $1.50 when from 2 to 4 feet high.

FIELD PLANTING AND SOWING.

Repeated efforts have been made by the Forest Service to establish plantations of incense cedar by sowing both broadcast and in seed pots but with indifferent success, owing to damage by rodents and drought and to many of the sites being unfavorable. Where conditions are favorable, however, planting with this species gives fair promise of success. Too little work has yet been done to determine conclusively the possibilities of field planting, but there is every reason to believe that with proper methods incense cedar can be planted successfully. The cost, however, will have to be reduced materially before field planting can be done at a profit that will justify its being attempted on a commercial scale by private individuals.

APPENDIX.

TABLE 19.—*Volume, in cubic feet, of incense cedar, based on total height, Plumas, Sequoia, Shasta, and Stanislaus National Forests, California.*

[CURVED.]

Diameter breasthigh.	Total height of tree (feet).										Average total height.	Basis number of trees.
	60	70	80	90	100	110	120	130	140	150		
	Total volume, cubic feet, outside bark.											
Inches.											*Feet.*	
16	42	45	48	.....	.....	.....	.....	.....	.....	.....	54	1
17	44	48	52	.....	.....	.....	.....	.....	.....	.....	58	.....
18	49	54	58	62	68	.....	.....	.....	.....	.....	62	7
19	54	59	64	69	74	.....	.....	.....	.....	.....	66	.....
20	59	65	71	76	82	.....	.....	.....	.....	.....	69	18
21	66	72	78	83	90	.....	.....	.....	.....	.....	72	.....
22	72	79	86	92	99	108	.....	.....	.....	.....	75	36
23	79	86	94	100	108	118	.....	.....	.....	.....	78	.....
24	86	94	102	109	118	128	.....	.....	.....	.....	81	43
25	94	102	111	118	128	138	.....	.....	.....	.....	84	.....
26	102	111	120	128	138	149	.....	.....	.....	.....	86	44
27	110	119	129	138	149	160	.....	.....	.....	.....	89	.....
28	119	128	138	149	160	173	185	200	215	.....	91	65
29	128	138	148	159	173	185	200	215	230	.....	93	.....
30	137	147	158	170	184	199	214	230	246	.....	95	84
31	147	157	168	182	196	213	228	245	262	.....	97	.....
32	156	167	189	193	209	227	242	260	278	.....	99	92
33	.....	.....	191	207	223	241	257	276	294	.....	101	.....
34	.....	.....	202	220	237	256	272	292	311	.....	103	81
35	.....	.....	216	233	251	271	288	308	328	.....	105	.....
36	.....	.....	227	247	265	286	304	325	347	.....	107	102
37	.....	.....	241	261	281	302	321	343	365	.....	109	.....
38	.....	.....	254	275	296	317	338	361	384	404	111	100
39	.....	.....	268	290	312	334	356	380	404	426	112	.....
40	.....	.....	283	305	327	350	374	398	424	442	114	62
41	.....	.....	297	320	343	367	393	428	445	470	116	.....
42	.....	.....	312	336	360	385	412	438	466	493	117	67
43	.....	.....	327	351	376	403	432	458	488	515	119	.....
44	.....	.....	341	367	393	421	450	479	519	539	120	75
45	.....	.....	.....	.....	410	440	470	500	531	563	122	.....
46	.....	.....	.....	.....	428	460	490	522	554	588	123	56
47	.....	.....	.....	.....	446	480	510	543	577	614	124	.....
48	.....	.....	.....	.....	469	500	530	565	601	649	125	33
49	.....	.....	.....	.....	483	519	551	587	625	665	126	.....
50	.....	.....	.....	.....	501	540	572	610	650	692	127	30
51	.....	.....	.....	.....	.....	.....	594	634	676	719	128	.....
52	.....	.....	.....	.....	.....	.....	617	658	702	747	129	21
53	.....	.....	.....	.....	.....	.....	640	683	728	774	130	.....
54	.....	.....	.....	.....	.....	.....	664	709	755	803	131	8
55	.....	.....	.....	.....	.....	.....	688	735	782	832	132	.....
56	.....	.....	.....	.....	.....	.....	712	762	809	862	133	12
57	.....	.....	.....	.....	.....	.....	738	789	838	893	134	.....
58	.....	.....	.....	.....	.....	.....	763	817	869	925	134	8
59	.....	.....	.....	.....	.....	.....	788	845	901	960	135	.....
60	.....	.....	.....	.....	.....	.....	815	875	934	995	136	7
61	.....	.....	.....	.....	.....	.....	842	904	966	1,030	136	.....
62	.....	.....	.....	.....	.....	.....	868	934	1,000	1,065	137	2
Total basis	38	170		327		331		155		33	.....	1,054

TABLE 20.—*Volume, in board feet, of incense cedar, based on total height, Plumas, Sequoia, Shasta, and Stanislaus National Forests, California.*

[CURVED.]

Diameter breasthigh.	Total height of tree (feet).																	Average height of tree.	Diameter inside bark of top.	Basis.
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200			
	Volume (board feet).																			
Inches.																		*Feet.*	*Inches.*	*Trees.*
16	50	60	80	100	110	120	140	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54	8	2
17	60	70	90	110	130	140	160	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	58	8	9
18	60	90	110	130	150	170	190	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	62	9	.....
19	70	100	120	150	170	200	220	240	.....	.....	.....	.....	.....	.....	.....	.....	.....	66	9	20
20	80	120	140	170	190	220	240	270	.....	.....	.....	.....	.....	.....	.....	.....	.....	69	9	.....
21	100	130	160	190	220	240	270	300	.....	.....	.....	.....	.....	.....	.....	.....	.....	72	9	37
22	110	150	180	210	240	270	300	330	370	.....	.....	.....	.....	.....	.....	.....	.....	75	9	.....
23	130	160	200	230	260	300	330	350	410	.....	.....	.....	.....	.....	.....	.....	.....	78	9	43
24	140	180	220	250	290	330	360	410	450	.....	.....	.....	.....	.....	.....	.....	.....	81	9	.....
25	160	200	240	280	320	360	400	450	510	560	.....	.....	.....	.....	.....	.....	.....	84	9	44
26	170	220	270	310	350	400	450	500	560	620	.....	.....	.....	.....	.....	.....	.....	86	9	.....
27	190	240	290	340	380	440	490	550	620	680	.....	.....	.....	.....	.....	.....	.....	89	9	67
28	210	260	320	370	420	480	540	610	680	740	810	.....	.....	.....	.....	.....	.....	91	9	.....
29	.....	290	350	400	460	520	590	660	740	800	880	.....	.....	.....	.....	.....	.....	93	9	87
30	.....	320	380	440	500	570	640	720	800	870	950	.....	.....	.....	.....	.....	.....	95	9	.....
31	.....	350	410	480	540	620	700	780	860	940	1,020	1,110	.....	.....	.....	.....	.....	97	9	96
32	.....	380	450	520	590	670	760	840	920	1,010	1,100	1,190	.....	.....	.....	.....	.....	99	10	.....
33	.....	.....	480	560	640	720	810	900	990	1,080	1,170	1,280	.....	.....	.....	.....	.....	101	10	84
34	.....	.....	520	600	680	770	870	960	1,060	1,160	1,250	1,360	1,470	.....	.....	.....	.....	103	10	.....
35	.....	.....	560	640	730	820	920	1,020	1,130	1,230	1,340	1,450	1,560	.....	.....	.....	.....	105	10	104
36	.....	.....	590	680	780	880	980	1,090	1,200	1,310	1,420	1,540	1,660	.....	.....	.....	.....	107	10	.....
37	.....	.....	.....	730	830	940	1,050	1,160	1,280	1,390	1,510	1,640	1,760	1,880	.....	.....	.....	109	10	102
38	.....	.....	.....	780	880	1,000	1,110	1,230	1,350	1,470	1,600	1,730	1,860	1,980	.....	.....	.....	111	10	.....
39	.....	.....	.....	830	940	1,060	1,180	1,300	1,430	1,560	1,690	1,830	1,960	2,090	.....	.....	.....	112	10	63
40	.....	.....	.....	880	1,000	1,120	1,250	1,380	1,510	1,640	1,780	1,920	2,060	2,200	2,340	.....	.....	114	10	.....
41	.....	.....	.....	.....	1,060	1,180	1,320	1,450	1,590	1,730	1,880	2,020	2,160	2,310	2,460	.....	.....	116	10	67
42	.....	.....	.....	.....	1,120	1,250	1,390	1,530	1,680	1,820	1,970	2,120	2,270	2,430	2,580	.....	.....	117	10	.....
43	.....	.....	.....	.....	1,180	1,320	1,460	1,610	1,760	1,910	2,070	2,220	2,380	2,550	2,710	2,860	.....	119	10	76
44	.....	.....	.....	.....	1,250	1,390	1,540	1,700	1,840	2,000	2,170	2,320	2,490	2,660	2,830	2,990	.....	120	10	.....
45	.....	.....	.....	.....	.....	1,460	1,620	1,780	1,930	2,100	2,270	2,430	2,600	2,780	2,960	3,120	.....	122	10	58
46	.....	.....	.....	.....	.....	1,530	1,690	1,860	2,020	2,190	2,360	2,540	2,720	2,900	3,080	3,270	3,420	123	10	.....
47	.....	.....	.....	.....	.....	1,600	1,770	1,940	2,120	2,290	2,460	2,650	2,840	3,020	3,210	3,380	3,560	124	10	34
48	.....	.....	.....	.....	.....	1,670	1,840	2,020	2,210	2,380	2,570	2,760	2,950	3,140	3,340	3,520	3,710	125	10	.....
49	.....	.....	.....	.....	.....	.....	1,920	2,110	2,300	2,480	2,680	2,870	3,070	3,270	3,480	3,660	3,860	126	10	33
50	.....	.....	.....	.....	.....	.....	2,000	2,190	2,390	2,580	2,790	2,990	3,190	3,390	3,610	3,810	4,010	127	10	.....

51							2,080	2,280	2,490	2,690	2,900	3,110	3,320	3,520	3,740	3,950	4,160	128	10	21
52							2,160	2,360	2,580	2,800	3,020	3,230	3,450	3,660	3,880	4,100	4,310	129	10	.....
53							.....	2,450	2,680	2,910	3,130	3,350	3,580	3,800	4,020	4,250	4,470	130	10	8
54							.....	2,550	2,780	3,020	3,250	3,480	3,720	3,940	4,170	4,410	4,640	131	10	.....
55							.....	2,640	2,880	3,130	3,370	3,610	3,860	4,080	4,320	4,570	4,800	132	11	12
56							.....	2,730	2,980	3,250	3,500	3,750	4,000	4,230	4,490	4,740	4,980	133	11	.....
57							.....	.....	3,090	3,370	3,630	3,890	4,150	4,390	4,060	4,920	5,170	134	11	8
58							.....	.....	3,200	3,490	3,750	4,030	4,300	4,560	4,830	5,100	5,370	134	11	.....
59							.....	.....	3,320	3,620	3,890	4,170	4,460	4,720	5,020	5,300	5,580	135	11	9
60							.....	.....	3,440	3,740	4,030	4,320	4,620	4,890	5,200	5,490	5,800	136	11	.....
Total basis	3		39		174		341		333		157		32		4		1	.....	.....	1,084

Average height of stump is between 1.6 and 3 feet; average length of logs scaled, 14.4 feet.

TABLE 21.—*Incense cedar, seedling growth (height-age), 1912.*

Total height.	Average age of all seedlings below the means.	Mean age.	Average age of all seedlings above the means.
Feet.	*Years.*	*Years.*	*Years.*
0.5	3	5	10
1.0	5	10	17
1.5	8	14	23
2.0	10	19	29
2.5	13	23	34
3.0	15	28	39
3.5	18	32	.....
4.0	20	36	.....
4.5	23	.....	.....

TABLE 22.—*Volume, in board feet, of incense cedar, based on number of 16-foot logs, Plumas, Sequoia, Shasta, and Stanislaus National Forests, California.*

[CURVED.]

Diameter breasthigh.	Number of 16-foot logs.								Average merchantable length.	Diameter inside bark of top.	Basis.
	2	3	4	5	6	7	8	9			
	Volume (board feet).										
Inches.									*Feet.*	*Inches.*	*Trees.*
14	70	130							23	8	
15	80	140							26	8	2
16	90	150							29	8	
17	100	170							32	8	8
18	110	180							34	9	
19	120	200	280						37	9	20
20	130	210	300						40	9	
21	140	230	320						42	9	38
22	160	250	340						45	9	
23	170	270	360	480					48	9	43
24	190	290	390	510					50	9	
25	210	310	420	540					52	9	43
26	230	340	450	570					55	9	
27	250	370	480	610	790				57	9	61
28	270	400	510	650	830				60	9	
29	300	430	550	690	870				62	9	76
30	330	460	590	730	920				64	9	
31	360	490	630	780	970	1,160			67	9	96
32	400	530	670	830	1,020	1,210			70	10	
33		570	720	880	1,070	1,260			72	10	84
34		610	760	940	1,120	1,310			74	10	
35		650	810	990	1,180	1,370			76	10	104
36		700	870	1,050	1,240	1,430			78	10	
37		750	920	1,110	1,310	1,500	1,690		80	10	102
38		800	980	1,170	1,370	1,570	1,780		82	10	
39		860	1,040	1,240	1,450	1,650	1,870		84	10	63
40		920	1,110	1,310	1,520	1,740	1,960		86	10	
41		980	1,180	1,380	1,600	1,830	2,060		88	10	67
42		1,040	1,250	1,460	1,690	1,920	2,170		90	10	
43			1,330	1,540	1,770	2,020	2,270	2,550	91	10	76
44			1,420	1,630	1,860	2,110	2,380	2,670	93	10	
45			1,500	1,730	1,960	2,210	2,490	2,800	94	10	58
46			1,590	1,820	2,050	2,310	2,600	2,930	96	10	
47			1,680	1,920	2,150	2,410	2,720	3,060	97	10	34
48			1,780	2,020	2,240	2,510	2,830	3,200	98	10	
49			1,870	2,110	2,340	2,620	2,960	3,350	100	10	33
50			1,970	2,210	2,440	2,740	3,080	3,500	101	10	
51			2,070	2,300	2,550	2,850	3,220	3,670	102	10	21
52			2,170	2,390	2,650	2,960	3,360	3,840	104	10	
53				2,470	2,750	3,080	3,500	4,020	105	10	8
54				2,550	2,850	3,200	3,650	4,200	106	10	
55				2,630	2,960	3,330	3,810	4,380	108	11	12
56				2,710	3,050	3,450	3,960	4,570	109	11	
57				2,790	3,150	3,580	4,120	4,770	110	11	8
58				2,860	3,250	3,700	4,290	4,970	111	11	
59				2,930	3,340	3,830	4,450	5,180	112	11	9
60				2,990	3,440	3,960	4,610	5,400	114	11	
Total basis...	370	1,670	2,650	2,550	1,930	1,090	330	70			1,066

Average height of stump is between 1.6 and 3 feet; average length of logs scaled, 14.4 feet.

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HENRY S. GRAVES, Forester

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LUMBER USED IN THE MANUFACTURE OF WOODEN PRODUCTS.

By J. C. Nellis, *Forest Examiner.*

The importance of the wood-working industries among the manufacturing industries of the country is indicated by the fact that lumber-working plants, of all classes, consume annually 24½ billion feet of wood. This is about 60 per cent of the annual lumber production of approximately 40 billion feet. The material is mostly lumber, but includes comparatively small quantities of veneer, bolts, and dimension stock.

This report presents statistics showing the average annual consumption of wood by the wood-working industries in the United States. The basic data were secured by a series of State wood-using industry studies. Those for the more important States have been published separately. Although the State studies were begun in 1909 and were not completed until 1913, a period of 12 months was made the basis for the statistics for each State, and the final figures for the whole country here presented are therefore a very good average of the demand of each industry and the demand for each kind of wood.

Lumber usually is remanufactured to a greater or less extent before use, and in this report the product of the sawmill is not considered. However, planing mills operated in connection with sawmills manufacture large quantities of flooring, ceiling, siding, finish and other patterns which really are finished products, and such material accordingly is covered by the statistics.

About 40 per cent of the annual lumber cut is not worked by planing mills or factories into finished products. About one-fifth of this (in normal times) is exported, while the rest is used in general building and rough construction. Though all construction lumber requires cutting to length to make it fit into place, this industry was not considered by the studies, which canvassed only the wood-working factories. All imported woods used by factories are included in the statistics.

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The wood-using studies were intended to supplement the annual reports on the consumption of wood for lath, shingles, cooperage, veneer, pulp, distillation, poles, and ties, and these industries therefore are not covered in this report.

In the case of Louisiana, Arkansas, Minnesota, Montana, Idaho, Washington, and Oregon, the basis for compiling the figures for planing-mill products differs from the general plan of including only planing-mill patterns, in that nearly all dressed lumber, surfaced on from one to four sides, is also included in the figures for these States.

Figure 1 shows graphically the comparative amounts used by each important industry in each State.

Figure 2 shows graphically the comparative amounts of each important wood used in each State.

Table 1 gives detailed figures by industries and shows the amount of each kind of wood used by each industry.

The scope of the statistics for the industries with titles that are not entirely descriptive is as follows: Planing-mill products cover standard patterns such as flooring, ceiling, and siding made in large quantities by planing mills in lumber-producing regions, while sash, doors, blinds, and millwork usually are made in millwork plants in the consuming regions. However, considerable quantities of doors and door stock are made in the Pacific Coast States. Boxes and crates cover all kinds of packing boxes and crates made of lumber or veneer, and also fruit and vegetable packages and baskets. Car construction covers wooden construction in all types of railroad and electric cars, as well as in locomotives and mine cars. Furniture includes household and office furniture, except chairs, kitchen furniture, and fixtures in business buildings. Vehicles take in horse vehicles, automobiles, bicycles, pushcarts, and wheelbarrows. Woodenware and novelties embrace a thousand or more articles, such as kitchen utensils, wooden dishes, butter and cheese packages, measures, pails, wooden novelties of all kinds, ladders, and supplies for dairymen, poulterers, and apiarists. Fixtures are such as show cases, counters, bars, and lodge and church furnishings. Shade and map rollers include also curtain and rug poles and venetian blinds. Machine construction means wooden construction in machinery of all kinds. Shoe lasts, pegs, and shanks are boot and shoe findings. Four-sevenths of the wood used for professional and scientific instruments went for pencils, the rest for artists', photographers', and draftsmen's instruments, rules, and scientific apparatus. Billiard and pool tables, as well as gymnasium goods and all outdoor sporting goods, come under sporting and athletic goods. Mine equipment includes ventilating apparatus, brattices, breaker equipment, slope rollers, and sprags. Dowels are small rods used in fastening together furniture, fixtures, and doors. Under playground equipment come lawn swings and porch furniture.

The kinds of wood are classified according to rather broad commercial practice. The classification is practically the same as that used in the lumber census bulletins; figures on the several species of each family or group are combined under the common name.

Oak, maple, spruce, hemlock, birch, hickory, basswood, ash, elm, cedar,[1] willow, locust, and eucalyptus each covers its different species.

Yellow pine includes the southern yellow pines, North Carolina pines, and minor eastern yellow pines. Western yellow pine is listed separately; trade names for it are western pine, western soft pine, and California white pine.

White pine covers both northern and western (Idaho) white pine as well as Norway pine and jack pine.

Cottonwood takes in the cottonwoods, aspen (or popple), and balm of Gilead.

Tupelo includes cotton gum (called tupelo commercially), black gum, and water gum.

Larch includes western larch and eastern tamarack.

Mahogany covers all woods sold in this country as such.

White fir includes the botanical white fir as well as grand and silver (amabilis) fir; the other minor firs, noble, red, and alpine fir, usually sold as white fir, are listed separately.

All other kinds of wood listed are single species except that cypress, sycamore, cherry, dogwood, magnolia (cucumber, of the magnolia family, is shown separately), and buckeye are family names, but only one species of each is used commercially. Redwood sometimes includes lumber from the bigtree. The red-gum tree yields both commercial red and sap gum and both are covered herein by red gum.

[1] Spanish cedar is listed separately.

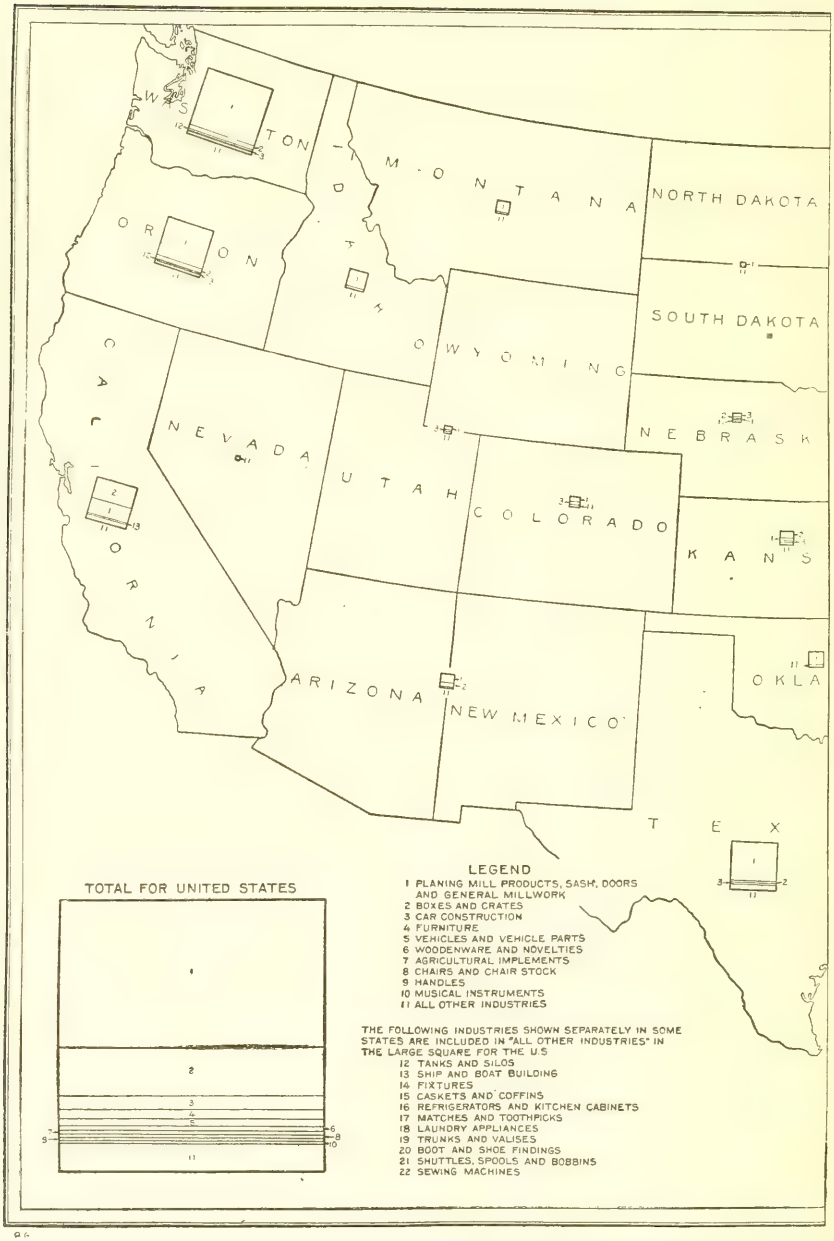
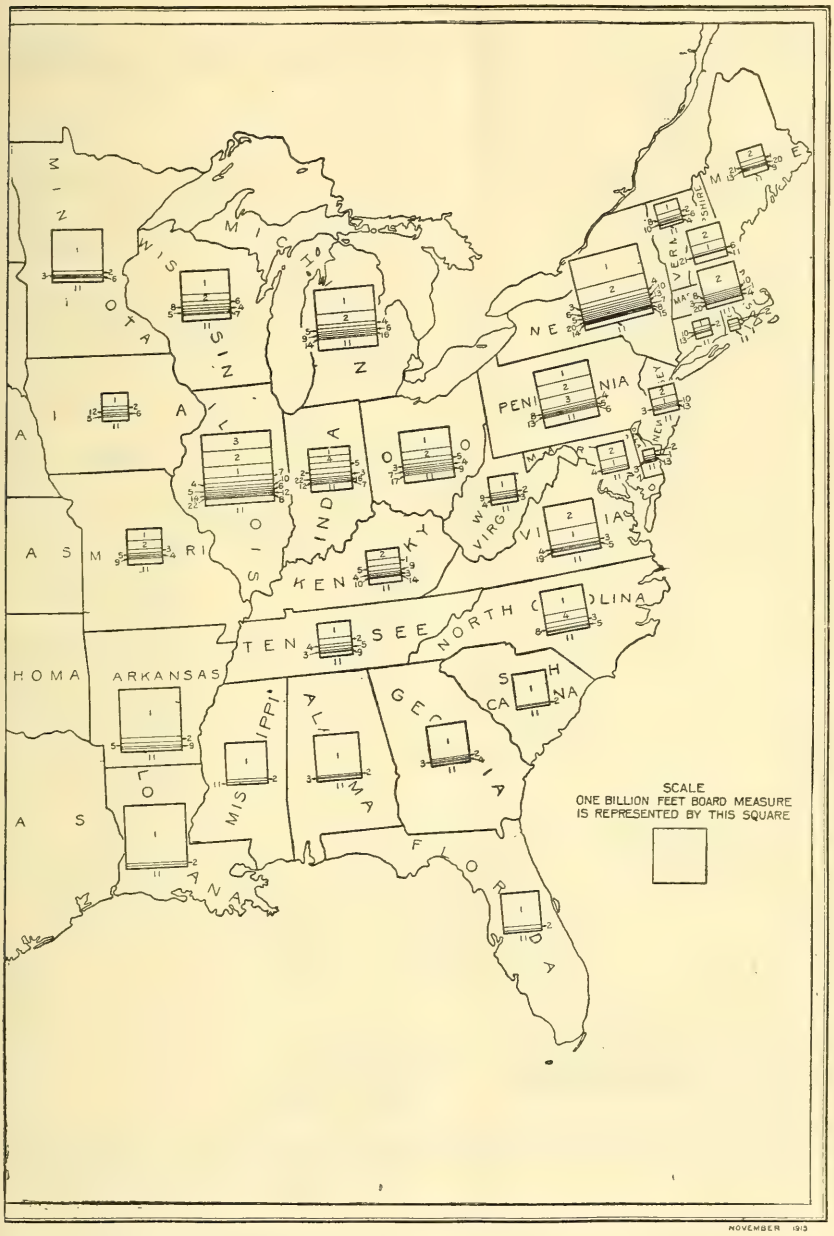


FIG. 1.—The annual consumption of wood by the



wood manufacturing industries (by industries).

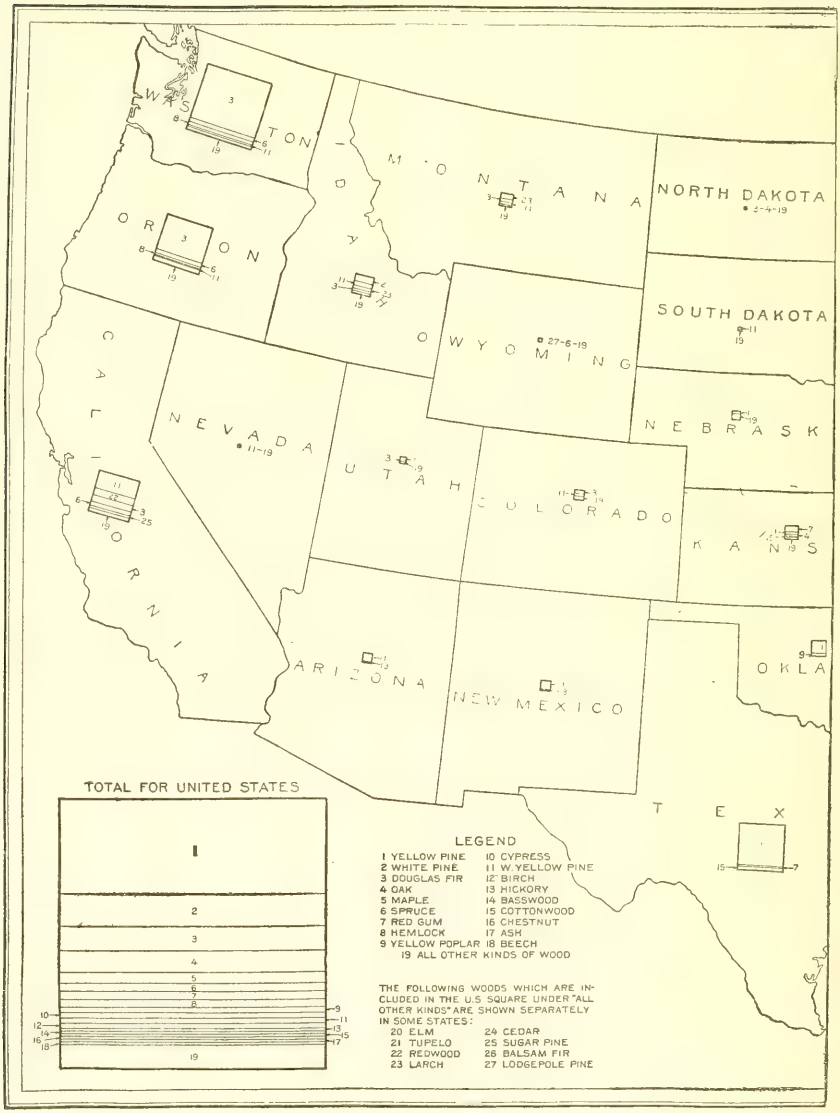
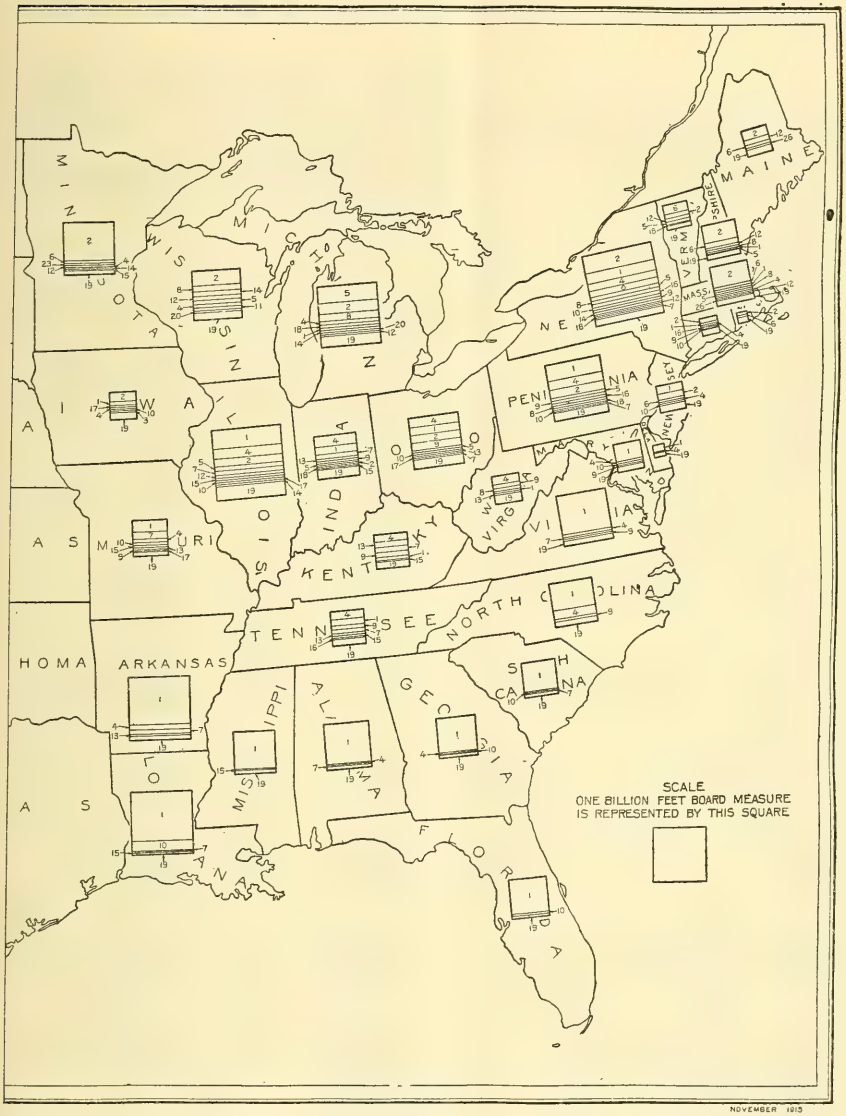


FIG. 2.—The annual consumption of wood by the



wood manufacturing industries (by kinds of wood).

TABLE 1.—*Quantity of each kind of wood used annually*

Industry.	Kind of wood.			
	Total.	Yellow pine.	White pine.	Douglas fir.
	Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
All industries	24,576,556,564	8,610,685,624	3,112,698,017	2,273,788,484
Planing-mill products, sash, doors, blinds, and general millwork.	13,428,862,066	6,447,780,805	1,543,345,756	1,991,177,352
Boxes and crates	4,550,016,430	1,044,993,123	1,131,969,940	7,349,840
Car construction	1,262,090,371	678,114,162	75,382,166	86,544,784
Furniture	944,677,807	18,926,400	9,332,808	11,387,790
Vehicles and vehicle parts	739,144,483	31,205,478	1,675,277	930,610
Woodenware, novelties, and dairymen's, poulterers', and apiarists' supplies.	405,286,436	18,566,406	47,744,797	2,005,175
Agricultural implements	321,239,336	98,453,396	8,243,440	2,537,250
Chairs and chair stock	289,790,560	20,000	815,068	65,000
Handles	280,234,571	67,000	25,500	247,200
Musical instruments	260,195,026	2,107,994	9,394,820	480,400
Tanks and silos	225,619,686	41,291,700	17,007,600	89,705,322
Ship and boat building	199,598,228	65,698,652	14,256,006	44,342,081
Fixtures	187,132,848	11,612,365	4,864,150	5,512,310
Caskets and coffins	153,394,557	11,970,650	33,170,942	6,000
Refrigerators and kitchen cabinets	137,616,266	7,872,931	8,613,186	543,600
Matches and toothpicks	85,442,111	.....	73,059,611	.....
Laundry appliances	79,502,040	1,397,000	3,026,870	184,500
Shade and map rollers	79,291,575	1,150,000	61,450,000	3,000,000
Paving material and conduits	76,067,000	65,092,000	1,850,000	3,500,000
Trunks and valises	74,667,997	15,277,990	7,299,500	.....
Machine construction	69,459,430	22,461,088	5,405,405	985,100
Boot and shoe findings	66,240,200	.....	.....	.....
Picture frames and molding	65,477,783	5,498,000	5,812,300	6,000
Shuttles, spools, and bobbins	65,148,190	.....	130,000	.....
Tobacco boxes	64,127,476	.....	199,425	.....
Sewing machines	59,946,527	65,000	.....	.....
Pumps and wood pipe	55,826,938	373,230	12,524,000	21,351,480
Pulleys and conveyors	35,862,900	250,000	285,000	129,000
Professional and scientific instruments	35,070,928	46,600	601,670	30,000
Toys	28,926,552	.....	2,367,131	.....
Gates and fencing	27,450,540	6,765,000	3,883,500	805,000
Sporting and athletic goods	25,191,907	943,000	805,300	85,000
Patterns and flasks	24,299,403	1,951,447	17,854,635	54,090
Bungs and faucets	21,112,342	.....	287,000	.....
Plumbers' woodwork	20,313,450	262,250	786,500	.....
Electrical machinery and apparatus	18,188,910	1,264,900	3,022,700	138,000
Mine equipment	16,987,697	1,263,000	239,000	.....
Brushes	12,878,986	.....	75,000	.....
Dowels	11,980,500	.....	25,000	.....
Elevators	10,018,680	3,622,868	1,692,450	415,200
Saddles and harness	9,218,000	.....	10,000	130,500
Playground equipment	9,064,812	1,448,012	42,000	1,000
Butchers' blocks and skewers	8,197,050	.....	200,000	.....
Clocks	7,894,249	926,571	476,064	.....
Signs and supplies	6,888,366	428,856	3,266,950	36,000
Printing material	5,324,794	337,000	11,550	.....
Weighing apparatus	5,021,550	1,180,750	168,000	102,900
Whips, canes, and umbrella sticks	4,946,880	.....	.....	.....
Brooms and carpet sweepers	2,277,334	.....	.....	.....
Firearms	2,093,901	.....	.....	.....
Artificial limbs	687,080	.....	.....	.....
Tobacco pipes	489,515	.....	.....	.....
Airplanes	74,300	.....	.....	.....

in the manufacture of wooden products.

Kind of wood—Continued.								
Oak.	Maple.	Spruce.	Red gum.	Hemlock.	Yellow poplar.	Cypress.	Western yellow pine.	Birch.
Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
1,983,584,491	919,420,274	805,050,195	797,343,658	708,752,769	680,936,848	668,353,342	563,816,810	481,293,680
501,367,772	317,634,231	350,528,295	121,366,583	442,050,165	236,047,697	508,728,575	264,920,778	133,867,989
56,362,111	96,831,648	335,935,643	402,121,640	203,526,091	165,416,737	38,962,895	288,291,927	90,787,900
305,276,814	5,789,298	8,799,060	1,035,640	12,455,379	32,439,064	1,676,400	4,242,500	5,830,429
431,053,289	87,571,456	2,270,500	102,237,867	7,053,446	53,374,580	3,477,800	1,806,985	54,677,450
212,918,361	35,863,267	835,650	26,650,314	448,678	48,665,960	1,320,951	182,300	14,227,125
7,716,860	38,255,880	28,591,148	8,358,296	2,136,522	7,278,889	8,693,450	262,500	29,547,890
69,346,130	48,319,210	2,623,500	11,976,000	1,257,400	12,412,300	2,682,000	219,000	4,704,000
135,269,118	47,264,747	10,000	8,790,280	216,000	1,140,000	.....	30,000	30,114,332
12,458,472	41,238,446	18,000	6,654,300	500,000	211,900	122,000	.....	9,908,250
20,638,480	45,482,775	29,144,150	9,243,825	615,600	40,371,925	70,000	.....	12,349,055
5,642,401	200,000	10,233,500	1,085,000	1,777,000	240,000	35,408,575	127,000	.....
32,382,311	1,014,167	7,783,980	164,000	4,745,775	448,077	5,014,741	518,500	1,055,167
62,681,744	20,701,026	2,016,816	5,491,170	473,300	14,574,881	3,364,550	961,720	15,255,129
7,544,255	110,000	1,700,000	7,010,520	1,985,000	9,640,860	19,157,633	543,500	191,000
31,351,521	6,375,242	5,555,690	13,483,400	6,934,872	5,985,729	1,700,500	50,000	3,628,106
.....	1,200,000	750,000	.....	.....	500,000	.....	.....	3,575,000
427,500	14,219,000	2,301,000	3,395,000	1,300,000	1,026,200	15,321,300	5,000	3,876,500
294,000	879,925	7,063,000	2,065,200	.....	326,000	20,000	.....	93,000
4,500	5,047,000	1,759,850	1,783,005	7,000,000	2,988,500	1,275,000	361,000	71,500
8,295,864	3,597,981	729,775	206,500	3,268,191	2,208,577	15,868,405	2,000	470,406
3,000	54,050,000	.....	.....	.....	190,000	.....	.....	7,483,000
16,043,423	309,150	325,000	7,675,040	.....	2,158,814	451,000	.....	3,133,700
39,000	13,531,450	.....	270,000	.....	701,000	.....	.....	33,192,000
403,200	96,450	.....	6,898,270	.....	7,358,919	1,559,027	.....	.....
19,106,250	324,148	.....	20,774,280	.....	8,039,244	.....	.....	206,000
565,800	1,706,000	.....	3,089,628	.....	1,974,000	2,055,000	.....	55,500
7,343,500	2,436,000	177,000	19,677,500	200,000	400,000	3,000	5,000	745,000
372,100	4,425,167	16,000	75,500	.....	1,001,400	23,000	8,000	1,062,056
1,444,057	3,964,400	1,300	523,000	241,000	882,000	150,000	.....	3,123,950
2,640,700	140,000	1,071,000	.....	5,152,000	5,000	681,040	33,000	300,000
2,497,559	4,913,815	191,800	150,000	180,600	970,200	166,000	.....	983,233
182,200	118,150	478,238	1,000	580,600	344,330	74,000	136,500	7,000
250,000	854,900	110,000	325,000	.....	18,010,000	.....	1,200	305,000
14,031,200	388,300	.....	416,000	.....	819,000	25,000	.....	2,404,500
4,936,000	1,190,650	1,980,700	202,500	257,600	561,700	201,000	.....	804,200
4,826,472	949,200	.....	250,100	2,328,750	86,500	.....	.....	336,075
90,900	1,911,897	.....	284,800	.....	282,265	30,000	7,000	1,913,000
77,000	1,354,500	.....	15,000	.....	.....	.....	90,000	8,149,000
956,200	1,562,262	73,000	.....	1,003,800	334,600	10,000	10,000	28,000
1,248,000	1,450,500	.....	1,078,500	.....	22,200	.....	1,400	10,000
2,576,800	854,000	100,000	30,000	.....	85,000	.....	.....	147,500
12,000	2,145,650	.....	1,750,600	.....	.....	.....	.....	240,000
2,637,027	80,000	.....	37,000	.....	1,085,000	.....	.....	52,044
12,000	101,500	10,000	200,000	1,060,000	100,600	30,000	1,000,000	.....
272,100	703,786	.....	15,000	.....	150,000	30,000	.....	242,200
158,000	451,000	1,820,000	.....	5,000	73,000	500	.....	675,000
20,000	1,101,100	.....	20,000	.....	.....	.....	.....	580,000
405,000	564,500	.....	110,000	.....	.....	.....	.....	530,500
.....	.....	.....	345,000	.....	.....	.....	.....	.....
.....	147,100	.....	.....	.....	.....	.....	.....	353,000
.....	.....	.....	12,000	.....	.....	.....	.....	2,000
3,500	.....	46,600	.....	.....	4,200	.....	.....	.....

TABLE 1.—*Quantity of each kind of wood used annually*

Industry.	Kind of wood.			
	Hickory.	Basswood.	Cottonwood.	Chestnut.
	Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
All industries	389,604,531	369,640,782	322,642,796	298,849,801
Planing-mill products, sash, doors, blinds, and general millwork	2,489,288	60,557,122	21,428,700	82,267,497
Boxes and crates	767,920	86,979,611	210,519,509	36,216,700
Car construction	1,226,706	5,148,521	3,037,468	825,074
Furniture	843,600	33,146,276	5,158,309	44,734,180
Vehicles and vehicle parts	239,491,910	6,418,308	33,278,658	972,809
Woodenware, novelties, and dairymen's, poulterers', and apiarists' supplies	1,567,011	58,563,923	13,315,296	20,853,100
Agricultural implements	9,860,470	7,861,750	15,143,000	884,000
Chairs and chair stock	1,192,200	1,758,338	126,000	5,240,630
Handles	120,294,466	2,285,885	27,000	10,000
Musical instruments	225	10,968,180	2,351,000	38,125,141
Tanks and silos		5,000		15,000
Ship and boat building	110,195	959,000	14,026	751,295
Fixtures	26,000	7,114,755	1,553,351	8,039,595
Caskets and coffins		2,728,038	555,000	46,586,629
Refrigerators and kitchen cabinets	150,000	5,221,634	4,420,322	1,508,753
Matches and toothpicks		5,575,000	375,000	
Laundry appliances		4,980,670	7,991,500	20,500
Shade and map rollers	2,500	702,500		460,000
Paving material and conduits				
Trunks and valises	173,700	21,164,406	1,973,325	562,500
Machine construction	1,113,135	1,155,403	293,000	272,375
Boot and shoe findings	25,000	3,599,200	5,000	
Picture frames and molding	10,000	20,340,700	1,000	1,314,650
Shuttles, spools, and bobbins	872,000	1,947,000	175,000	
Tobacco boxes		4,206,250	6,750	
Sewing machines		310,000	326,912	540,000
Pumps and wood pipe	925,000			
Pulleys and conveyors		625,000	42,000	120,000
Professional and scientific instruments	971,332	2,619,070	170	367,000
Toys		8,739,242	257,000	966,268
Gates and fencing	600	50,000		5,121,500
Sporting and athletic goods	4,944,000	318,600	60,000	222,000
Patterns and flasks		123,500		175,200
Bungs and faucets	6,000			
Plumbers' woodwork		245,000		114,000
Electrical machinery and apparatus		299,000	7,500	112,700
Mine equipment	816,363			854,405
Brushes	125,000	758,300	50,000	31,500
Dowels	30,500	167,500	5,000	
Elevators	100	10,000		19,000
Saddles and harness	12,800	52,000	46,000	
Playground equipment	100,000			
Butchers' blocks and skewers	1,310,000			
Clocks		1,415,000		290,000
Signs and supplies		100,000	100,000	
Printing material	20,500	352,600		255,800
Weighing apparatus		35,000		
Whips, canes, and umbrella sticks	84,000	32,500		
Brooms and carpet sweepers				
Firearms				
Artificial limbs	40,010	1,000		
Tobacco pipes				
Airplanes	2,000			

in the manufacture of wooden products—Continued.

Kind of wood—Continued.								
Ash.	Beech.	Elm.	Tupelo.	Redwood.	Larch.	Cedar.	Sugar pine.	Balsam fir.
Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
295,461,482	278,203,632	218,200,988	127,958,309	122,326,779	114,029,275	102,248,253	59,211,298	53,262,030
21,304,374	58,394,284	6,218,860	17,003,448	92,759,519	88,484,081	45,187,611	31,795,077	10,863,300
10,507,308	77,899,280	63,726,458	74,982,910	2,439,500	7,470,300	2,512,150	24,686,000	40,173,700
18,163,433	1,873,700	1,221,121	114,168	120,000	1,537,669	339,487	61,328	700,750
15,668,588	21,163,204	12,154,102	2,529,000	355,250	154,000	1,856,100	375,510	.....
43,974,668	5,497,743	31,296,922	1,067,600	259,000	.....	2,500	6,000	1,000
62,635,800	14,101,553	16,383,426	5,366,900	3,208,150	416,700	6,405,470	419,063	586,880
10,677,400	4,968,490	7,249,000	1,140,000	200,500	100,000	.....	50,000	.....
2,765,050	27,187,621	23,157,586	191,000	.....	.....	34,500	.....	.....
64,156,872	16,691,207	3,060,307	.....	.....	.....	.....	.....	.....
2,377,332	4,186,000	15,602,440	460,000	286,200	.....	17,500	1,004,400	101,400
866,000	150,000	15,000	20,000	8,124,938	9,745,000	4,549,400	10,750	.....
7,985,554	219,366	706,600	138,490	837,500	328,525	6,999,722	200,500	.....
2,783,822	1,109,000	6,368,275	248,000	1,074,710	2,000	977,345	206,650	.....
20,000	.....	.....	500,000	1,782,000	.....	5,901,718	.....	.....
19,066,380	787,000	13,046,100	39,500	161,000	56,000	.....	.....	710,000
.....	.....	.....	.....	.....	.....	407,500	.....	.....
111,500	9,580,000	1,365,000	3,842,000	13,000	.....	4,867,000	2,000	100,000
161,150	362,000	.....	1,006,000	2,000	.....	5,000	30,000	.....
.....	.....	.....	1,050,000	.....	4,475,000	100,000	.....	.....
534,435	520,000	6,409,286	.....	.....	.....	6,000	11,000	25,000
1,404,362	711,000	831,000	27,500	58,500	.....	100	4,000	.....
.....	445,000	2,000	.....	.....	.....	.....	.....	.....
281,845	1,200,595	43,000	240,000	47,632	.....	.....	2,730	.....
437,000	3,523,500	.....	250,000	.....	.....	.....	.....	.....
.....	.....	1,809,000	10,376,217	61,000	.....	246,750	.....	.....
.....	.....	.....	2,200,000	16,000	.....	.....	.....	.....
975,500	52,500	20,000	529,500	9,117,500	512,000	.....	.....	.....
512,100	1,976,000	200,000	639,000	.....	.....	.....	.....	.....
123,600	1,259,600	200	12,000	31,220	.....	20,050,000	23,500	.....
895,300	3,221,506	2,042,055	5,000	.....	.....	.....	.....	.....
700	.....	155,000	.....	133,000	48,000	465,500	.....	.....
3,180,000	212,000	3,226,750	20,000	.....	.....	222,500	.....	.....
35,000	10,500	40,000	500	1,033,200	.....	265,400	294,350	.....
.....	850,000	.....	.....	2,000	.....	30,000	.....	.....
536,000	.....	55,000	.....	.....	.....	.....	.....	.....
87,000	425,000	463,000	.....	.....	700,000	735,000	.....	.....
43,425	1,195,525	8,800	3,589,760	.....	.....	.....	.....	.....
36,400	6,378,894	187,000	1,000	.....	.....	24,000	3,440	.....
29,000	1,834,000	175,000	.....	.....	.....	18,000	.....	.....
145,700	.....	68,500	15,000	36,000	.....	.....	15,000	.....
2,103,000	2,658,600	276,000	20,000	.....	.....	.....	10,000	.....
180,000	3,083,500	334,000	1,000	.....	.....	.....	.....	.....
20,000	920,000	.....	.....	.....	.....	.....	.....	.....
.....	9,714	.....	322,816	.....	.....	.....	.....	.....
.....	.....	200,000	.....	147,460	.....	20,000	.....	.....
391,000	289,900	84,200	10,000	20,000	.....	.....	.....	.....
5,900	335,000	.....	.....	.....	.....	.....	.....	.....
30,000	2,822,500	.....	.....	.....	.....	2,000	.....	.....
236,984	98,350	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
12,000	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 1.—*Quantity of each kind of wood used annually*

Industry.	Kind of wood.			
	Mahogany.	Spanish cedar.	Sycamore.	Black walnut.
	Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
All industries	50,575,999	30,323,441	26,052,812	23,988,346
Planing-mill products, sash, doors, blinds, and general millwork	7,336,932	8,123	1,723,550	4,606,420
Boxes and crates	13,000		16,451,693	163,250
Car construction	5,986,198			256,181
Furniture	15,637,125	2,500	1,474,882	1,689,957
Vehicles and vehicle parts	516,399	500	62,600	390,450
Woodenware, novelties, and dairymen's, poulterers', and apiarists' supplies	72,305	10,000	607,500	38,547
Agricultural implements	500		290,000	8,000
Chairs and chair stock	2,455,700		971,344	263,200
Handles	29,000		156,000	29,050
Musical instruments	8,610,355	7,750	304,600	4,991,808
Tanks and silos				
Ship and boat building	1,190,192	27,300	38,000	3,750
Fixtures	5,527,819		713,000	660,635
Caskets and coffins	1,528,294	300		474,000
Refrigerators and kitchen cabinets	6,800		340,000	
Matches and toothpicks				
Laundry appliances			2,000	20,000
Shade and map rollers	5,000		202,000	2,000
Paving material and conduits				
Trunks and valises	500		5,000	
Machine construction	5,885			10,817
Boot and shoe findings				
Picture frames and molding	171,200		30,000	125,004
Shuttles, spools, and bobbins				
Tobacco boxes	161,200	30,203,068	430,000	
Sewing machines	91,878		150,000	7,796,815
Pumps and wood pipe				
Pulleys and conveyors				
Professional and scientific instruments	84,862			71,200
Toys			91,343	
Gates and fencing				
Sporting and athletic goods	100,000	31,500	30,500	41,000
Patterns and flasks	271,659	31,400		21,500
Bungs and faucets				56,000
Plumbers' woodwork	127,000			10,300
Electrical machinery and apparatus	301,700			452,600
Mine equipment				
Brushes	35,300	1,000	74,300	26,700
Dowels				
Elevators	1,000			
Saddles and harness			34,500	
Playground equipment				
Butchers' blocks and skewers			1,600,000	
Clocks	204,196			58,527
Signs and supplies				
Printing material	48,500			
Weighing apparatus	4,000			
Whips, canes, and umbrella sticks	15,000			20,000
Brooms and carpet sweepers	30,500		270,000	500
Firearms				1,700,135
Artificial limbs				
Tobacco pipes				
Airplanes	6,000			

in the manufacture of wooden products—Continued.

Kind of wood—Continued.								
Cherry.	White fir.	Willow.	Dogwood.	Noble fir.	Magnolia.	Buckeye.	Persimmon.	Cucumber.
Feet b. m. 12,047,210	*Feet b. m.* 11,338,580	*Feet b. m.* 10,664,770	*Feet b. m.* 7,518,177	*Feet b. m.* 6,653,500	*Feet b. m.* 6,156,500	*Feet b. m.* 5,486,047	*Feet b. m.* 3,571,760	*Feet b. m.* 2,660,700
1,674,235	8,162,250	266,000	6,000	.....	116,900	694,400	.....	1,415,800
170,500	3,142,080	10,004,600	.....	6,653,500	5,449,000	3,174,028	.....	524,000
1,965,570	.....	.....	.....	.....	.....	.....	.....	.....
622,530	.....	40,000	.....	.....	477,100	415,000	35,000	16,000
39,650	3,000	.....	.....	.....	9,500	63,419	.....	3,800
62,350	31,250	128,000	34	.....	.....	83,700	.....	650,000
300	.....	.....	.....	.....	.....	.....	.....	1,100
56,000	.....	.....	.....	.....	.....	.....	.....	.....
617,500	.....	19,000	190,230	.....	.....	.....	7,000	.....
334,180	.....	.....	.....	.....	.....	6,000	.....	.....
500	.....	.....	.....	.....	.....	.....	.....	.....
184,976	.....	1,000	.....	.....	.....	.....	.....	.....
2,231,750	.....	150,000	.....	.....	27,000	10,000	.....	.....
33,000	.....	.....	.....	.....	.....	207,500	.....	20,000
7,500	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
2,000	.....	.....	.....	.....	.....	125,000	.....	.....
2,000	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	415,000	.....	.....
60,500	.....	.....	.....	.....	.....	.....	.....	.....
25,000	.....	.....	.....	.....	.....	.....	413,000	.....
10,000	.....	.....	.....	.....	.....	214,000	.....	20,000
5,000	.....	.....	7,060,425	.....	.....	.....	2,909,760	.....
.....	.....	.....	.....	.....	75,000	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	10,000
732,750	.....	.....	31,200	.....	.....	.....	.....	.....
2,000	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
600	.....	.....	6,000	.....	.....	.....	206,000	.....
165,594	.....	.....	.....	.....	.....	3,000	.....	.....
92,400	.....	.....	.....	.....	.....	.....	.....	.....
27,800	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	147,288	.....	.....	.....	.....	.....
488,900	.....	.....	9,000	.....	2,000	.....	1,000	.....
10,000	.....	.....	1,000	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
15,000	.....	.....	67,000	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
300,000	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	75,000	.....	.....
2,089,625	.....	.....	.....	.....	.....	.....	.....	.....
7,500	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
10,000	.....	56,170	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 1.—*Quantity of each kind of wood used annually*

Industry.	Kind of wood.			
	Butternut.	Red alder.	Lodgepole pine.	Red fir.
	Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
All industries	2,310,793	2,248,700	1,979,500	1,854,830
Planing-mill products, sash, doors, blinds, and general millwork	231,700	436,000	969,500	524,000
Boxes and crates	578,000			1,328,330
Car construction	1,300		1,000,000	
Furniture	593,500	792,500	1,000	2,500
Vehicles and vehicle parts	11,500		8,000	
Woodenware, novelties, and dairymen's, poulterers', and apiarists' supplies	159,000	20,000		
Agricultural implements	10,000			
Chairs and chair stock	20,546	625,000		
Handles	2,000	361,700		
Musical instruments	98,100			
Tanks and silos				
Ship and boat building	78,237			
Fixtures	393,600			
Caskets and coffins	16,000		1,000	
Refrigerators and kitchen cabinets				
Matches and toothpicks				
Laundry appliances				
Shade and map rollers	5,000			
Paving material and conduits				
Trunks and valises				
Machine construction	5,000			
Boot and shoe findings				
Picture frames and molding				
Shuttles, spools, and bobbins				
Tobacco boxes				
Sewing machines				
Pumps and wood pipe				
Pulleys and conveyors	10,000	5,500		
Professional and scientific instruments	30,000			
Toys	10,000			
Gates and fencing				
Sporting and athletic goods				
Patterns and flasks	42,710			
Bungs and faucets	14,600			
Plumbers' woodwork				
Electrical machinery and apparatus				
Mine equipment				
Brushes				
Dowels				
Elevators				
Saddles and harness		8,000		
Playground equipment				
Butchers' blocks and skewers				
Clocks				
Signs and supplies				
Printing material				
Weighing apparatus				
Whips, canes, and umbrella sticks				
Brooms and carpet sweepers				
Firearms				
Artificial limbs				
Tobacco pipes				
Airplanes				

in the manufacture of wooden products—Continued.

Kind of wood—Continued.								
Circassian walnut.	Padouk.	Hackberry.	Lignum-vitæ.	Teak.	West Indian boxwood.	Alpine fir.	Locust.	Hornbeam.
Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
1,744,779	1,386,530	1,128,000	952,126	926,969	870,412	780,000	639,228	608,484
740,212	333,792	441,000		114,245		270,000	220,000	19,000
		315,000				500,000		
1,300	723,063			31,000				
452,040	230,100	70,000	593,663	1,690			2,000	15,000
16,820	1,000	100,000					110,350	126,000
14,857		150,000	1,000		2,100	10,000	50,500	10,000
								1,200
8,300	3,000							
			1,500		37,556		4,000	415,500
268,415					70,328			
25,000	8,375		10,631	764,309			215,028	
99,050	85,000	6,000	785	1,125			1,000	
5,000								
500								
100				2,000				
			961				2,500	100
7,000								
					103,440			
250								
			72,300					
			37,236	1,000	653,848			
25,000			234,050	10,000				
	1,600			1,600			500	
13,400							2,000	
							31,350	21,684
	600				3,140			
		46,000						
20,500								
47,035								

TABLE 1.—*Quantity of each kind of wood used annually*

Industry.	Kind of wood.				
	Ebony.	Osage orange.	Rose-wood.	Prima vera.	Sassafras.
	Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
All industries	528,812	520,076	471,734	380,568	360,268
Planing-mill products, sash, doors, blinds, and general millwork	50,600	.....	6,100	121,973	336,000
Boxes and crates	.....	.....	.....	.....	.....
Car construction	.....	30,000	37,000	25,350	.....
Furniture	5,450	1,000	15,280	67,500	12,000
Vehicles and vehicle parts	.....	439,026	1,100	.....	.....
Woodenware, novelties, and dairymen's, poulterers', and apiarists' supplies	1,045	50,000	3,613	.....	1,500
Agricultural implements	.....	.....	.....	.....	.....
Chairs and chair stock	.....	.....	.....	.....	.....
Handles	4,664	.....	15,456	.....	.....
Musical instruments	60,373	.....	49,645	4,300	.....
Tanks and silos	.....	.....	.....	.....	.....
Ship and boat building	.....	50	1,600	31,750	50
Fixtures	1,800	.....	52,925	129,595	10,000
Caskets and coffins	.....	.....	.....	.....	718
Refrigerators and kitchen cabinets	.....	.....	.....	.....	.....
Matches and toothpicks	.....	.....	.....	.....	.....
Laundry appliances	.....	.....	.....	.....	.....
Shade and map rollers	.....	.....	1,000	100	.....
Paving material and conduits	.....	.....	.....	.....	.....
Trunks and valises	.....	.....	.....	.....	.....
Machine construction	.....	.....	.....	.....	.....
Boot and shoe findings	.....	.....	.....	.....	.....
Picture frames and molding	1,330	.....	2,420	.....	.....
Shuttles, spools, and bobbins	.....	.....	.....	.....	.....
Tobacco boxes	.....	.....	100	.....	.....
Sewing machines	.....	.....	.....	.....	.....
Pumps and wood pipe	.....	.....	.....	.....	.....
Pulleys and conveyors	.....	.....	.....	.....	.....
Professional and scientific instruments	500	.....	219,353	.....	.....
Toys	.....	.....	.....	.....	.....
Gates and fencing	.....	.....	.....	.....	.....
Sporting and athletic goods	189,000	.....	24,400	.....	.....
Patterns and flasks	.....	.....	.....	.....	.....
Bungs and faucets	.....	.....	10,642	.....	.....
Plumbers' woodwork	.....	.....	1,000	.....	.....
Electrical machinery and apparatus	.....	.....	2,260	.....	.....
Mine equipment	.....	.....	.....	.....	.....
Brushes	10,100	.....	12,050	.....	.....
Dowels	.....	.....	.....	.....	.....
Elevators	.....	.....	.....	.....	.....
Saddles and harness	.....	.....	.....	.....	.....
Playground equipment	.....	.....	.....	.....	.....
Butchers' blocks and skewers	.....	.....	.....	.....	.....
Clocks	.....	.....	290	.....	.....
Signs and supplies	.....	.....	.....	.....	.....
Printing material	.....	.....	.....	.....	.....
Weighing apparatus	.....	.....	.....	.....	.....
Whips, canes, and umbrella sticks	194,150	.....	.....	.....	.....
Brooms and carpet sweepers	.....	.....	5,500	.....	.....
Firearms	.....	.....	.....	.....	.....
Artificial limbs	.....	.....	10,000	.....	.....
Tobacco pipes	9,800	.....	.....	.....	.....
Airplanes	.....	.....	.....	.....	.....

in the manufacture of wooden products—Continued.

Kind of wood—Continued.										
Eucalyptus.	Applewood.	Cocobola.	Yucca.	Holly.	Laurel.	Satinwood.	Koko.	Turkish boxwood.	Miscellaneous foreign.	Miscellaneous native.
Feet b. m.	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*	*Feet b. m.*
338,800	320,935	279,400	172,300	86,680	72,400	67,958	32,600	29,189	630,345	432,158
4,200			60,000	500	1,600	34,000			106,125	261,750
	13,800		3,500							101,308
						288	32,000		46,000	
5,500	500			100	13,600	22,070			46,580	15,650
40,950	1,000								330	8,000
		2,400	69,000	60,000	4,200					12,450
10,000										10,000
	156,400	210,000						225	985	
1,000				3,580		5,100		25	625	
273,050	1,500	200			47,500				20,500	1,000
100					500	1,000	500		17,000	
						5,000				
							100			
4,000										
									2,250	
								1,575	40	
									36,600	
	300									
	25,000	64,800								
				1,500						
		2,000		21,000		500			1,000	
	1,000							33		
								25,600	30	
					5,000			1,731		
			39,800						30,000	
	121,435								322,280	22,000

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 606

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER April 15, 1918

RELATIVE RESISTANCE OF VARIOUS HARDWOODS TO INJECTION WITH CREOSOTE.

By CLYDE H. TEESDALE, *in charge, Section of Wood Preservation,* and J. D. MACLEAN, *Assistant Engineer in Forest Products.*

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PURPOSE OF THE EXPERIMENTS.

When wood is impregnated with preservatives some species are more easily penetrated than others, so that for proper treatment the species should be grouped according to their relative resistance to injection. Otherwise, part of a cylinder charge might receive a heavy treatment and another part a very light one. As wood structure is the most important factor in the grouping of woods for treatment, the Forest Service has made a study to determine its influence upon penetration with creosote. Such factors as the amount and location of sapwood, the moisture content, and the like, encountered in the commercial treatment of wood, also have an important bearing

NOTE.—Acknowledgment is made to Miss Eloise Gerry, microscopist, Forest Products Laboratory, for the portions of this bulletin describing the structure of the broad-leaved trees, and for assistance in examining the specimens after treatment. Acknowledgment is also made to Mr. F. J. Angier, superintendent timber preservation, Baltimore & Ohio Railroad Co.; Dr. Irving W. Bailey, Harvard University; Mr. John Foley, forester, Pennsylvania Railroad Co.; Dr. Kendrick W. Hatt, professor of civil engineering, Purdue University; Mr. A. R. Joyce, of the Joyce-Watkins Co.; Mr. V. K. Hendricks, assistant chief engineer, and Mr. O. C. Steinmeyer, supervisor of timber preservation, St. Louis & San Francisco Railroad; and Mr. J. H. Waterman, superintendent timber preservation, Chicago, Burlington & Quincy Railroad, for their generous assistance in reviewing the bulletin.

on penetration, but were purposely eliminated from this study in order that the variables introduced by the structure of the wood could be studied independently. This point should be kept in mind when applying the results to the treatment of wood in commercial plants.

The experiments were made at the Forest Products Laboratory, maintained by the Forest Service, United States Department of Agriculture, in cooperation with the University of Wisconsin. The results should assist in establishing a basis for the grouping of species to secure the best treatment and the most efficient use of the preservative.

This bulletin is a study of the resistance to injection with creosote of some of the more important hardwood species native to this country. A similar study on coniferous woods was published in Bulletin 101 of the Department of Agriculture.

STRUCTURE OF THE HARDWOODS.

The term "hardwoods" as here used means those trees which have comparatively broad leaves and do not bear cones. The hardwoods (Angiosperms) differ in structure from the softwoods or conifers[1] (Gymnosperms) chiefly in the possession of *pores* or *vessels* (tracheae). For this reason the conifers are frequently called *non-porous* woods and the hardwoods either *diffuse-porous* or *ring-porous*, according to the arrangement of the pores or vessels in the annual ring. The different varieties of specialized cells and fibers and the arrangement of the cells in less uniform rows make the structure of the hardwoods much more complex than that of the conifers.

GROSS STRUCTURE.

Sapwood and heartwood.—The lighter-colored layer of wood on the outer circumference of the tree contains the living cells, and is known as the sapwood. In some species, such as aspen, the difference in color between sapwood and heartwood is hardly noticeable. As trees grow older the cell walls tend to become more and more infiltrated with various substances, which are often responsible for the color of the heartwood. During the change from sapwood to heartwood alterations sometimes occur in the pores, which, as a result, have a tendency in most species to become clogged or closed up.

Annual rings.—Each year the tree adds a fresh layer of wood substance under the bark around its circumference. These layers are called annual rings. The part which is formed early in the year is called springwood; that which grows later in the season, summer-

[1] For a description of the wood of the conifers see Bulletin 101 of the Department of Agriculture.

wood. These rings are more or less conspicuous in the hardwoods of temperate regions, especially in those of the ring-porous group. In general, the springwood is more open and has fewer thick-walled cells than the summerwood.

Medullary rays.—The medullary rays (silver grain) which extend like the spokes in a wheel from the bark toward the pith at the center of the tree, are very conspicuous in some hardwoods, such as oak, beech, and sycamore.

MICROSCOPIC STRUCTURE.

The microscopic structure of the hardwoods is illustrated by Plates I, II, III, and IV.

Plate I is a photograph, taken through the microscope, of a section of maple. This wood belongs to the diffuse-porous group of hardwoods, which is so called because the pores or vessels (V) are scattered with considerable uniformity throughout the annual ring (AR). In this group the pores in the springwood (SP) are generally but little larger than those in the summerwood (SW).

Plate II shows red oak, an example of ring-porous wood. In the springwood of this species there is a noticeable group of large pores. When seen on the cross-section of a log these make conspicuous concentric rings around the pith. In this wood the pores are not distributed uniformly through the annual ring and there is a very considerable difference in the sizes of those in the springwood and the summerwood. The springwood pores in a ring-porous wood are usually considerably larger than the corresponding pores in a diffuse-porous wood.

Although these two species are typical of the two groups, yet in each group it is possible to find variations from the types of structure shown. Some diffuse-porous woods, for example, are more porous than maple; that is, they have more pores per square inch in proportion to the number of fibers and the like than others do. Some of the ring-porous woods have the large springwood vessels blocked with cell-like growths called tyloses[1] (T, Plate IV). These are visible to the naked eye as glistening fragments in the pores of such woods as white oak or hickory. Tyloses are also present in the diffuse-porous woods, although somewhat less abundantly and uniformly developed. They occur in the vessels which are not active in the transfer of sap; therefore, they are most numerous and completely developed in the older sapwood and the heartwood.

Medullary rays.—The medullary rays (MR) are generally rather conspicuous in the hardwoods, although in woods like aspen and

[1] "Tyloses: Their occurrence and practical significance in some American woods," Journal of Agricultural Research, Vol. I, March, 1914.

willow they are narrow as compared with those in sycamore, beech, and oak.

Wood prosenchyma (Wood fibers, etc.)—Wood prosenchyma, (indicated by "X" in the plates, consists of thick-walled elongated cells in the form of fibers or of spindle-shaped cells with pointed, interlocking ends. These specialized cells give the mechanical strength required in the tree. In the softwoods the fibers, or tracheids, serve both for the conduction of liquids and for mechanical support. In the hardwoods, however, these two functions are separated. The pores or vessels act as a specialized conducting tissue, and the wood prosenchyma, though it shares in sap conduction to a small degree, acts chiefly as mechanical support.

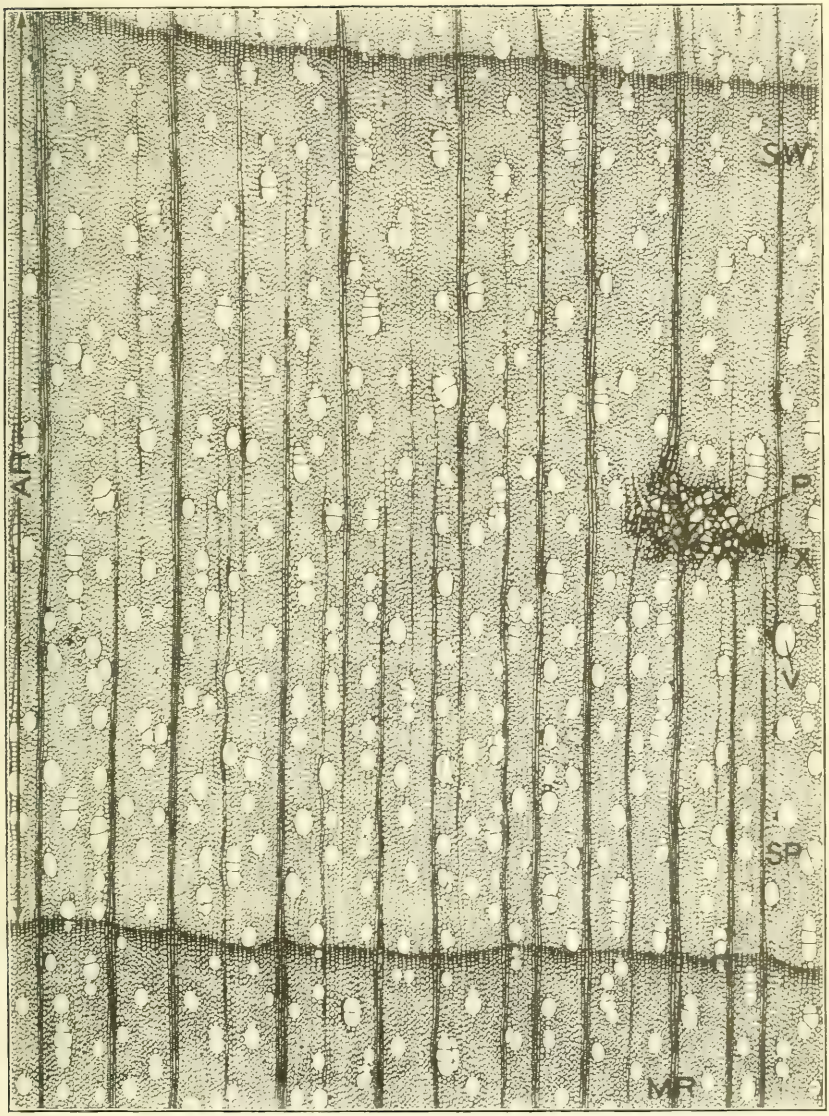
METHODS USED IN THE EXPERIMENTS.

The presence of large vessels, the extent to which these are blocked by tyloses and gums, and the presence of other infiltrating substances in the cell walls are known to be important factors in the impregnations of hardwoods with creosote. A very careful study was, therefore, made of these factors.

The resistance of the wood to treatment was studied in two kinds of tests: (1) Applying the creosote to a small area on a specimen and measuring the penetration in different directions, and (2) impregnation in a treating cylinder, blocks from each of the species being treated together in the same run. After treatment the specimens were examined under the microscope to determine the influence of the wood structure on penetration.

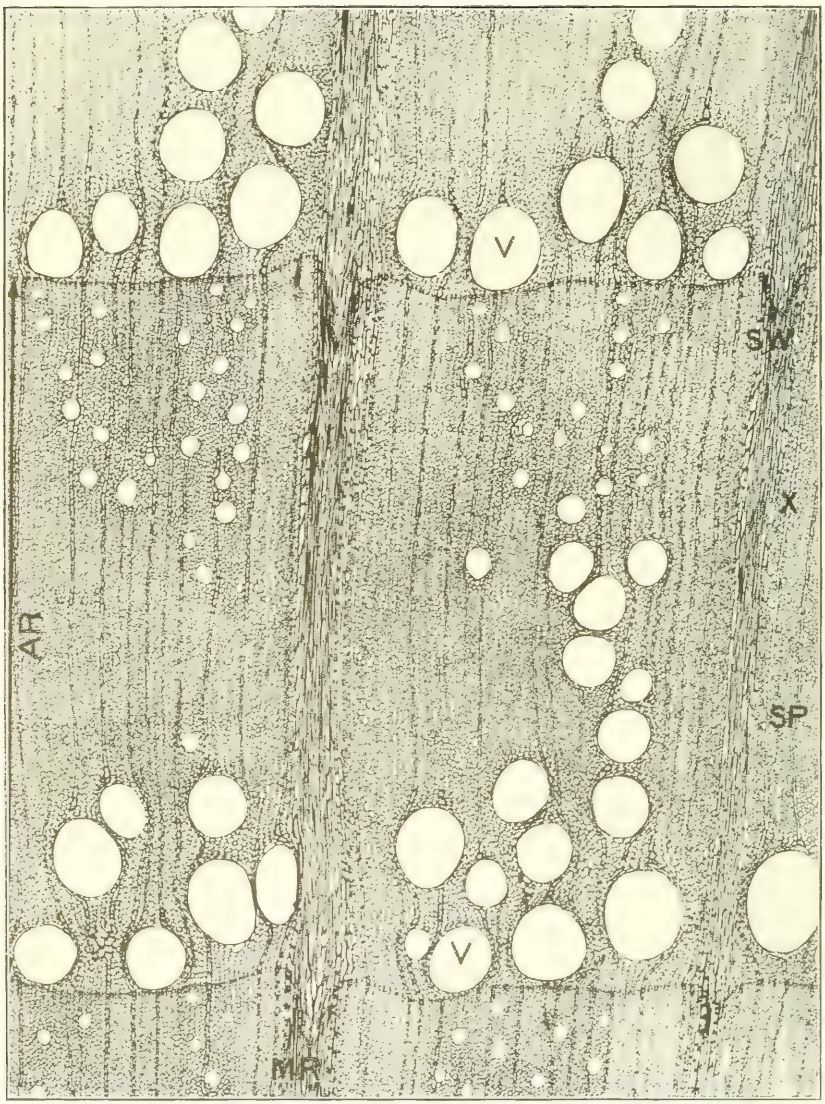
APPARATUS.

The penetrance apparatus in which the first series of tests was made is illustrated in figure 1. A hole three-fourths of an inch deep was bored in one face of the test specimen and the piece then clamped with the hole directly over the open end of pipe A, which led to the bottom of pressure tank B. The pipe and the lower portion of the tank were filled with creosote. Pressure was obtained by means of compressed air admitted through pipe C. A pressure regulator, K, was used to maintain a uniform pressure during the test. The apparatus was inclosed in a wooden oven having double glass windows in the front and back. Steam coils, J, heated the specimens and preservative to a constant temperature, which duplicated as nearly as possible the temperature conditions of a treating cylinder. Pressure and temperature were measured by gauge G and thermometer H. The specimens were placed on shelves in the apparatus and heated to a uniform temperature before testing. By the use of the



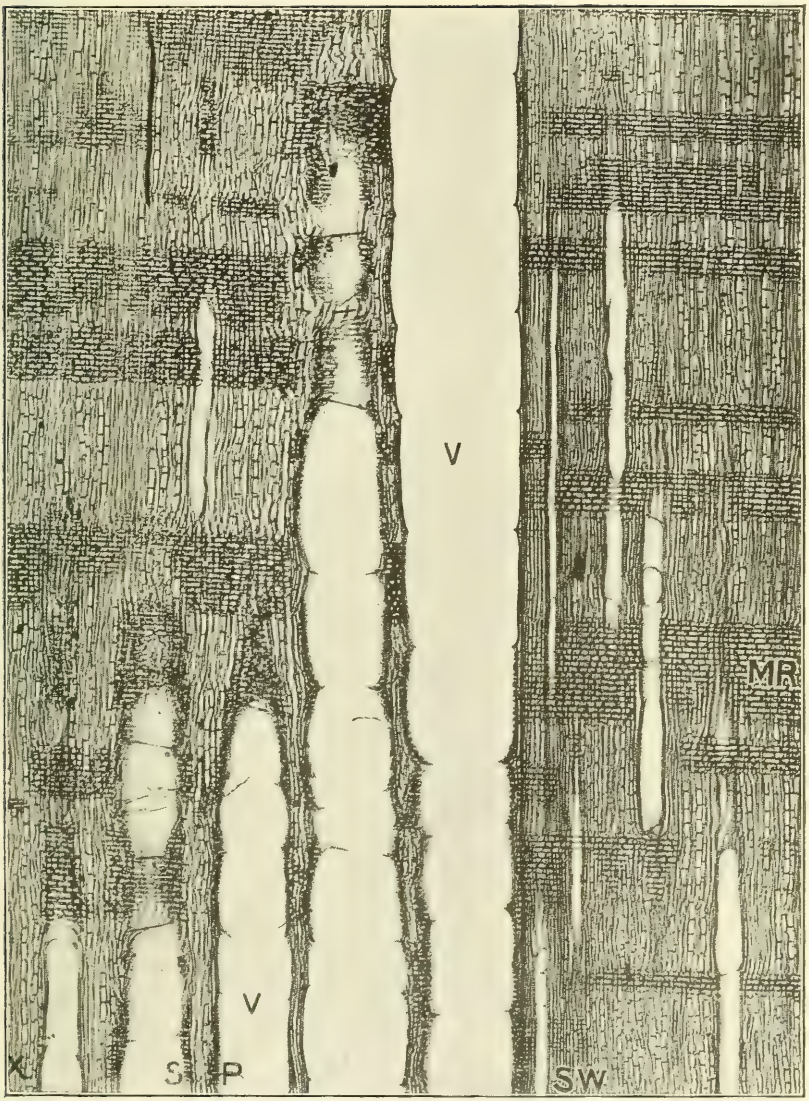
MAPLE (CROSS SECTION, MAGNIFIED 50 DIAMETERS). A DIFFUSE-POROUS WOOD.

AR, annual ring; *SP*, springwood; *SW*, summerwood; *MR*, medullary ray; *P*, pith fleck; *V*, pores or vessels; *X*, wood prosenchyma (fibers, etc.).



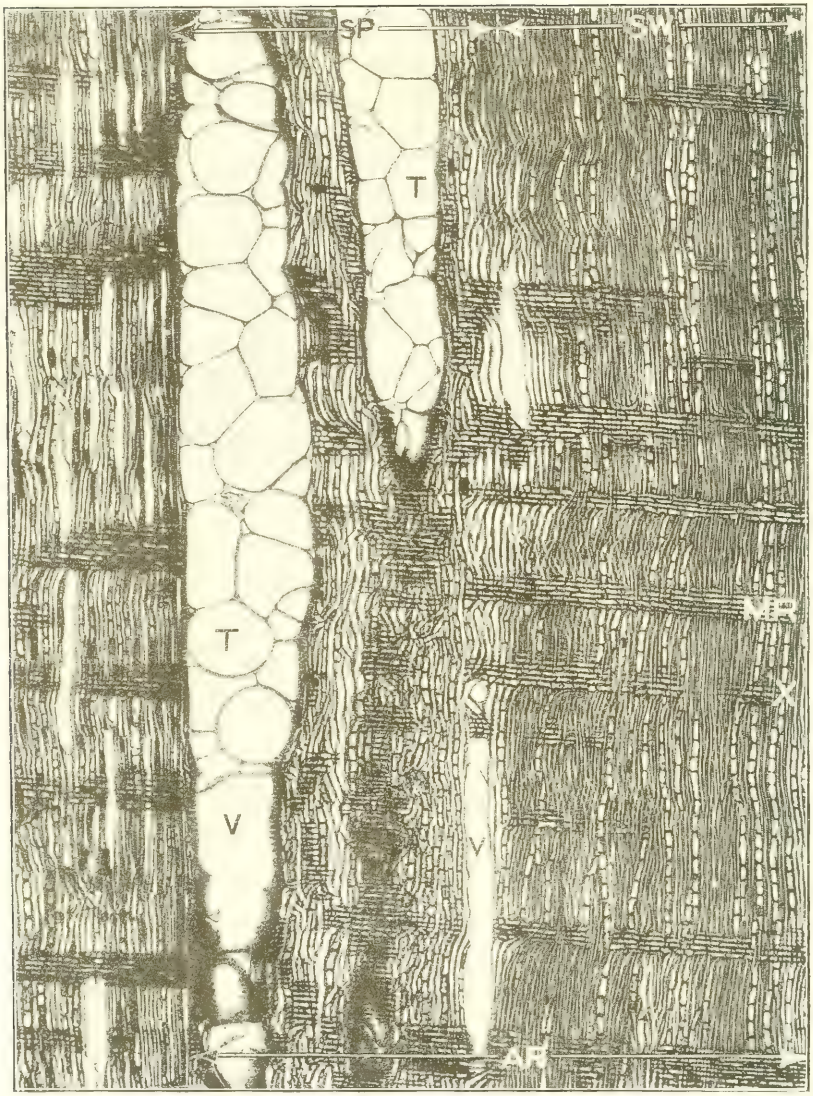
RED OAK (CROSS SECTION, MAGNIFIED 50 DIAMETERS). A RING-POROUS WOOD.

AR, annual ring; *SP*, springwood; *SW*, summerwood; *MR*, medullary ray; *V*, pores or vessels; *X*, wood prosenchyma (fibers, etc.).



RED OAK (RADIAL SECTION, MAGNIFIED 50 DIAMETERS).

SP, springwood; *SW*, summerwood; *MR*, medullary ray; *V*, pores or vessels; *X*, wood prosenchyma (fibers, etc.).



POST OAK, A WHITE OAK (RADIAL SECTION, MAGNIFIED 50 DIAMETERS).

SP, springwood; *SW*, summerwood; *ME*, medullary ray; *V*, pores or vessels; *X*, wood prosenchyma (fibers, etc.); *T*, tyloses.

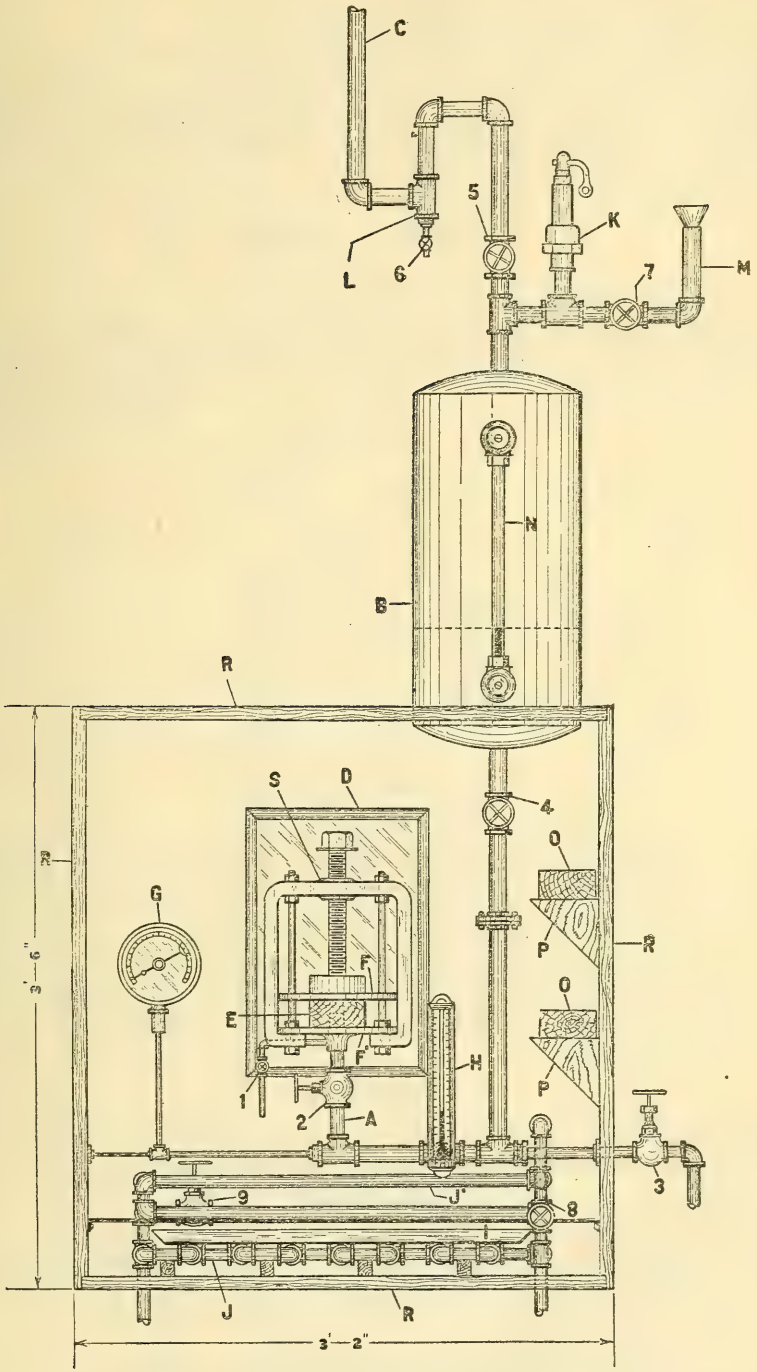


FIG. 1.—Apparatus for making penetrance tests.

mirror D, placed at the back of the oven, it was possible to observe both ends of the specimen during the test.

The impregnation tests were made in a cylinder 1½ feet in diameter and 4 feet long. Temperature and pressure were controlled by means of steam coils and a pressure pump. The specimens were separated from each other during treatment, so that all parts of the wood were in contact with the preservative.

MATERIALS USED.

CREOSOTE.

The creosote used was a coal-tar product with a specific gravity of 1.071 at 140° F. (60° C.) and a viscosity, determined by the Engler viscosimeter, of 1.2 at 160° F. (71° C.). The distillation[1] was as follows:

Temperature.	Distillation.
° C.	*Per cent.*
0–205	1.2
205–235	22.7
235–245	5.7
245–275	9.9
275–305	11.5
305–360	27.6
Residue	20.9
Loss	.5
Total	100.0

The creosote was obtained by distilling a by-product coke oven tar (Semet Solvay) to a very hard pitch. The indices of refraction at 60° C. and sulphonation tests are rather low for a pure coal-tar creosote, probably because the tar was produced in comparatively low-temperature ovens. The residue was a soft, sticky pitch, indicating the presence of a small amount of undistilled tar (probably less than 5 per cent).

WOOD.

The wood used in the experiments was selected from 25 species of hardwoods. In order to make the results comparable, all of the specimens for the different experiments on a given species were taken from the same log and matched as closely as possible. Most of the specimens used in the tests were heartwood, as sapwood specimens of sufficient size were available from only four of the species used.

[1] For method of analyses see Forest Service Circular 188, p. 36.

Three pieces of heartwood were selected from each species for the penetrance tests. Similarly, three specimens of sapwood were used of those species from which sapwood was available. The pieces were approximately 2½ inches by 1½ inches by 48 inches. Each specimen was surfaced on 4 sides, and a hole ¾ of an inch deep bored in the center of a 2½ inch by 48 inch face. All specimens were first thoroughly air-seasoned, and then dried for 48 hours at a temperature of 150° F. before treatment. The oven-dry weight and moisture content were determined at the time of treatment.

Specimens used in the impregnation tests were cut approximately 2½ inches by 1½ inches by 24 inches. Seven selected specimens of heartwood from each species were treated. The same number of sapwood pieces of the species from which sapwood could be obtained were also treated.

The following species were tested:

Common name.	Botanical name.	Locality from which obtained.
Ash, green	*Fraxinus lanceolata* Borkh	Missouri.
Ash, white	*Fraxinus americana* L	New York.
Aspen, largetooth	*Populus grandidentata* Michx	Wisconsin.
Basswood	*Tilia americana* L	Do.
Beech [1]	*Fagus atropunicea* (Marsh.) Lud.	Pennsylvania.
Birch, river (red)	*Betula nigra* L	[2]
Birch, sweet	*Betula lenta* L	Pennsylvania.
Birch, yellow	*Betula lutea* Michx. f	Do.
Cherry, wild red	*Prunus pennsylvanica* L	Tennessee.
Chestnut	*Castanea dentata* (Marsh.) Borkh.	Do.
Elm, cork or rock	*Ulmus racemosa* Thomas	Pennsylvania.
Elm, slippery	*Ulmus pubescens* Walt	Wisconsin.
Elm, white	*Ulmus americana* L	Pennsylvania.
Gum, red	*Liquidambar styraciflua* L	Missouri.
Gum, tupelo	*Nyssa, sp*	Louisiana.
Hackberry	*Celtis occidentalis* L	Wisconsin.
Hickory, mockernut	*Hicoria alba* (L.) Britt	[2]
Maple, silver	*Acer saccharium* L	Wisconsin.
Maple, sugar	*Acer saccharum* Marsh	Pennsylvania.
Oak, bur	*Quercus macrocarpa* Michx	Wisconsin.
Oak, chestnut	*Quercus prinus* L	Tennessee.
Oak, red	*Quercus rubra* L	Pennsylvania.
Oak, white	*Quercus, alba* L	Arkansas.
Sycamore	*Platanus occidentalis* L	Tennessee.
Willow, black	*Salix nigra* Marsh	Wisconsin.

[1] Red and white heart beech are botanically the same species.

[2] Obtained by purchase in the market. Locality of growth not known.

METHOD OF APPLYING THE CREOSOTE.

PENETRANCE TESTS.

In the penetrance tests a pressure of 120 pounds per square inch and a temperature of from 175° to 180° F. were employed. Readings of temperature and pressure were made every 15 minutes, and

the time was recorded at which the preservative first penetrated a surface. The periods of treatment were one-half hour, one hour, and two hours, respectively, for the three pieces from each species.

After treatment the specimens were sawed longitudinally and transversely along the center lines. (Fig. 2.) Immediately after sawing, the fresh surface was painted with water glass (sodium silicate solution) to prevent the creosote from staining the untreated surface. The longitudinal penetrations were measured on the surface obtained by sawing the specimens through the longitudinal center line. The average was obtained by measuring the area of the treated zone on this surface and dividing by the width of the penetration. The maximum and average radial and tangential penetrations were measured with a steel scale on the surface obtained by sawing the specimens transversely through the center line. These lines are indicated in figure 2; and Plates V to XII show specimens after being sawed. Radial and longitudinal penetrations were measured to the nearest 0.01 inch.

FIG. 2.—The general shape of the test pieces treated in the penetrance apparatus.

Photographs were taken of each specimen after treatment.

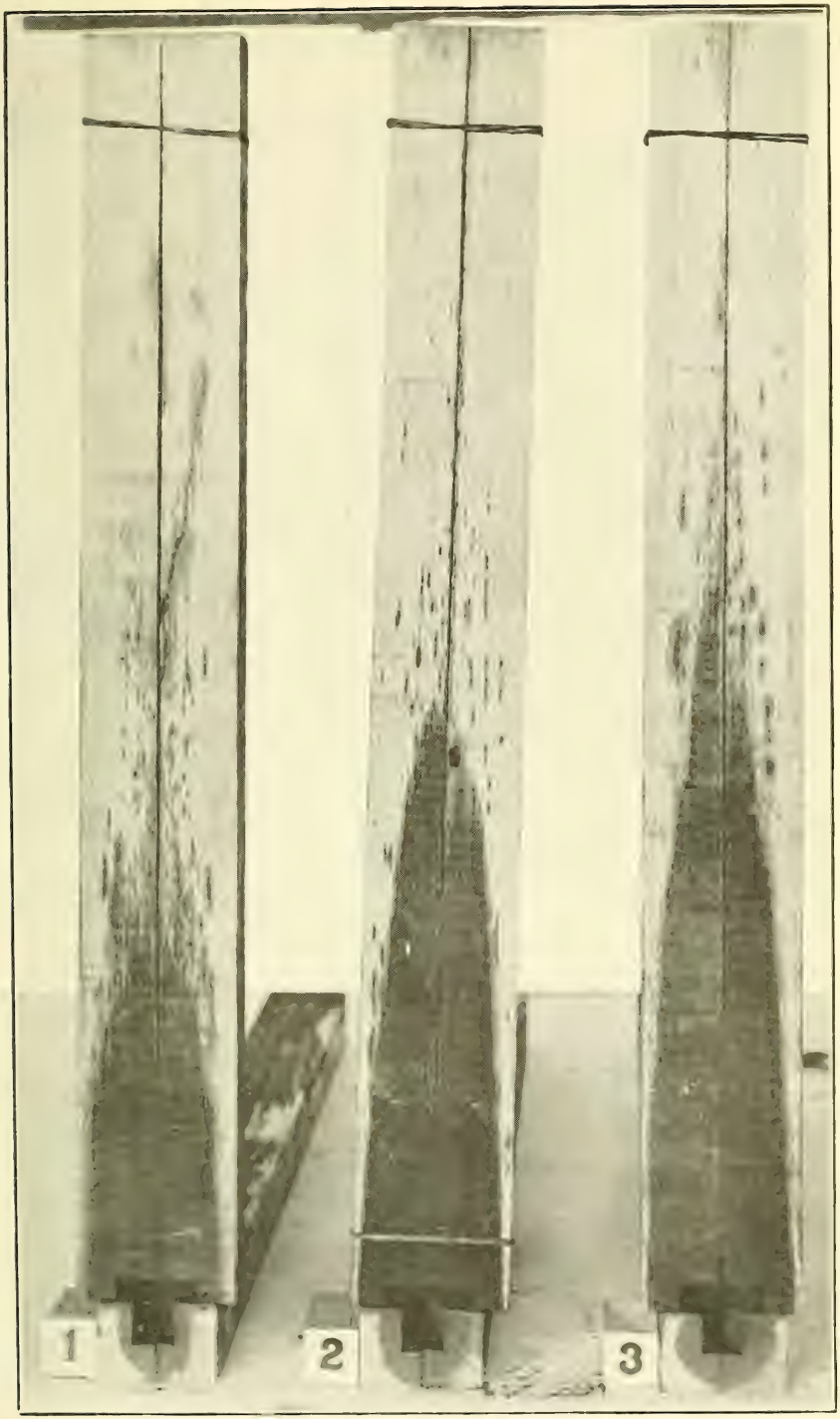
IMPREGNATION TESTS.

The impregnation tests comprised a series of seven treatments in which the pressure was varied and other conditions kept as nearly constant as possible. Each treatment was made on a heartwood specimen from each species. A sapwood specimen was also included from species having both sapwood and heartwood available.

The conditions of treatment are shown in Table 1.

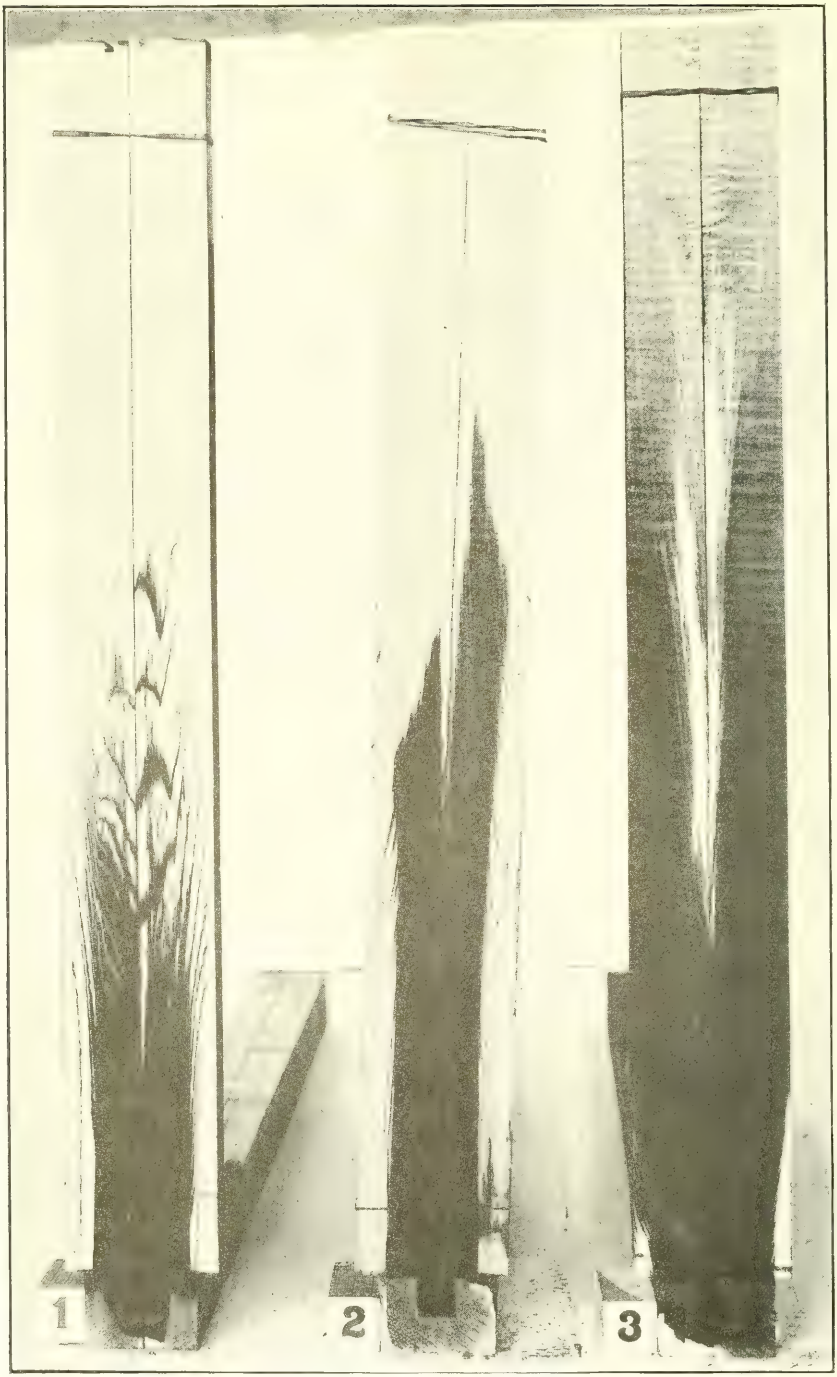
TABLE 1.—*The pressure, period, and temperature at which treatments were made.*

Run No.	Pressure.	Pressure period.	Temperature of preservative.
	Pounds per square inch.	*Hours.*	*°F.*
1	Atmospheric.	1	180–185
2	25	1	180–185
3	50	1	180–185
4	75	1	180–185
5	100	1	180–185
6	125	1	180–185
7	150	1	180–185



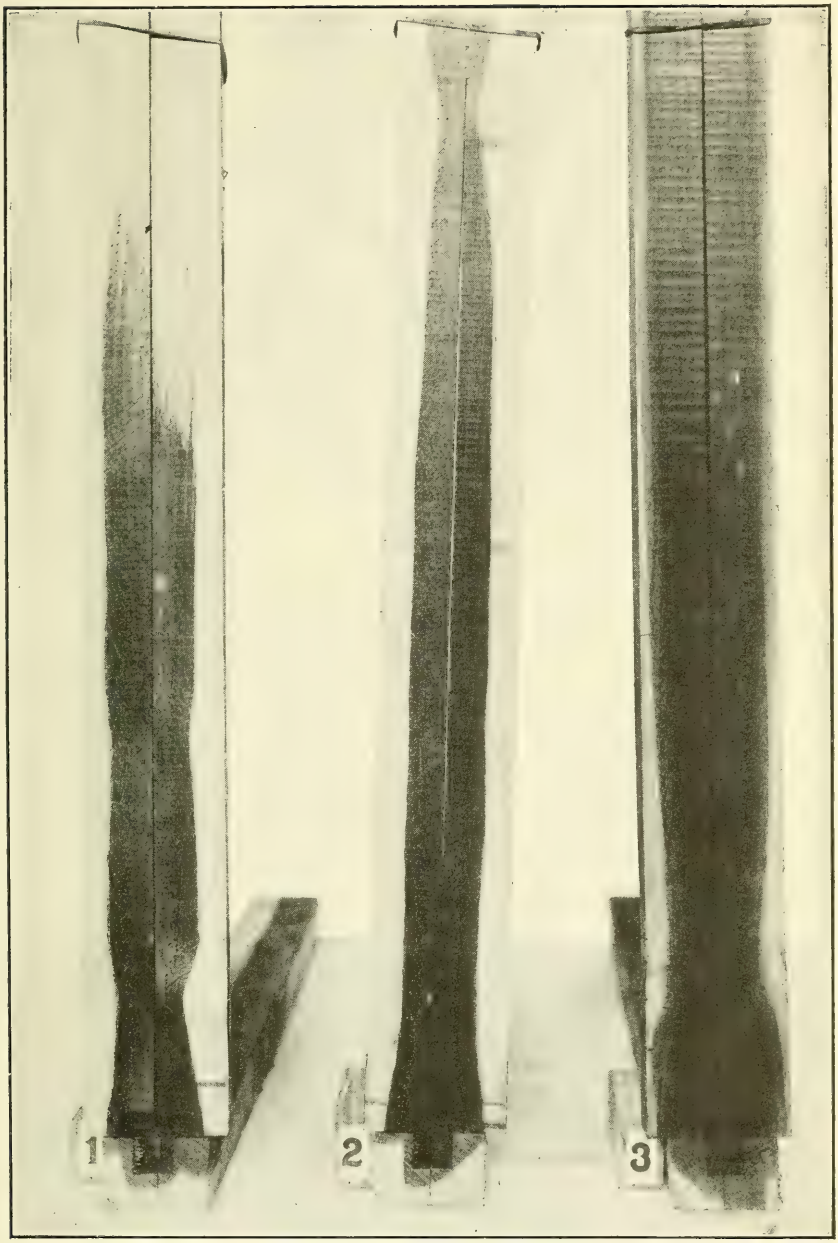
PENETRATION IN WHITE ASH—HEARTWOOD (FRAXINUS LANCEOLATA).

1, piece No. 66 treated 30 minutes; 2, piece No. 67 treated 60 minutes; 3, piece No. 68 treated 120 minutes. The thin-walled tyloses allowed the creosote to penetrate the vessels to some extent in addition to the penetration obtained in the wood prosenchyma. Spots on the untreated areas are points to which the creosote penetrated through the vessels.



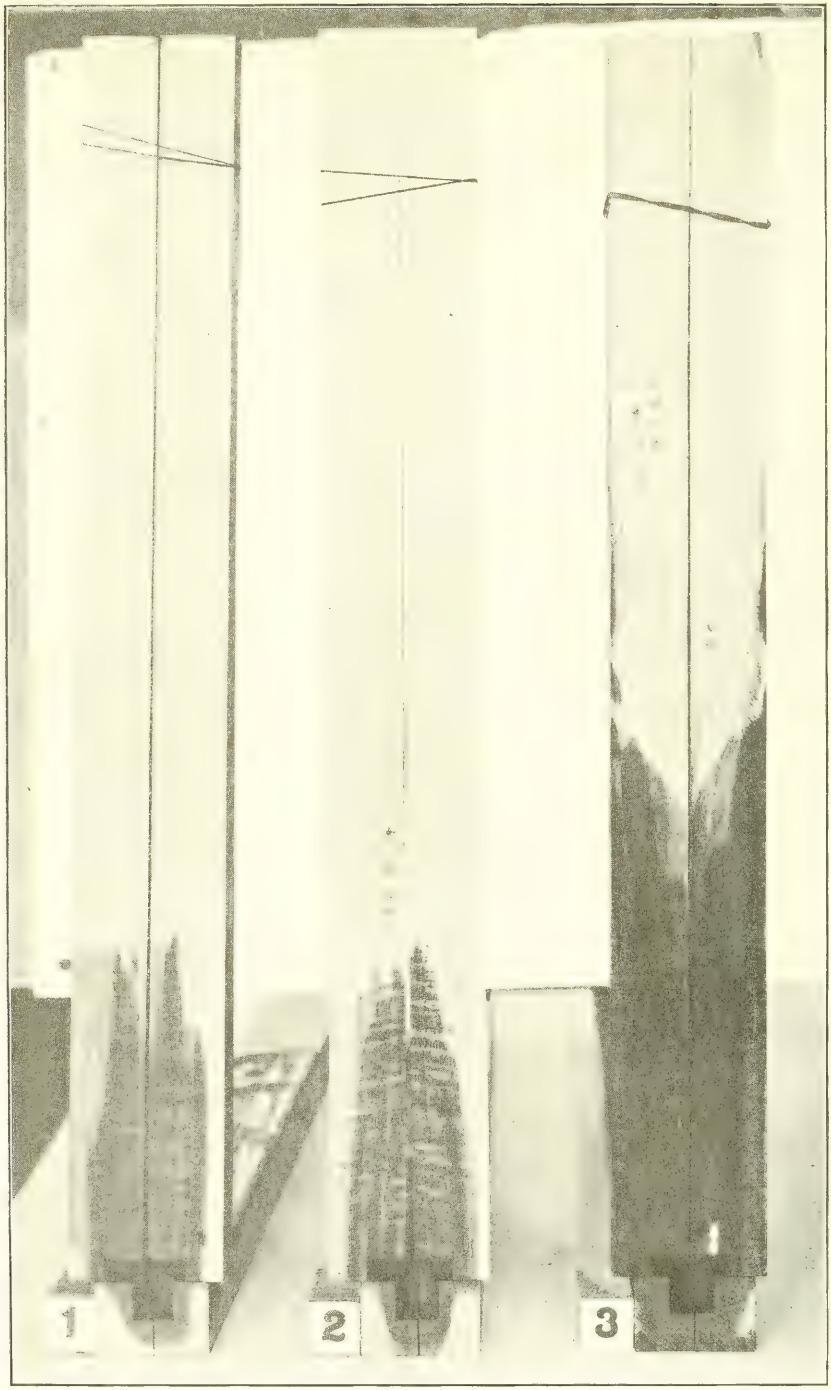
PENETRATION IN BASSWOOD—HEARTWOOD (TILIA AMERICANA).

1, piece No. 39 treated 30 minutes; 2, piece No. 40 treated 60 minutes; 3, piece No. 41 treated 120 minutes. Note the penetration of creosote in the summerwood first, in the piece on the left. Penetration took place readily in the summerwood because the wood prosenchyma is easily treated in this species.



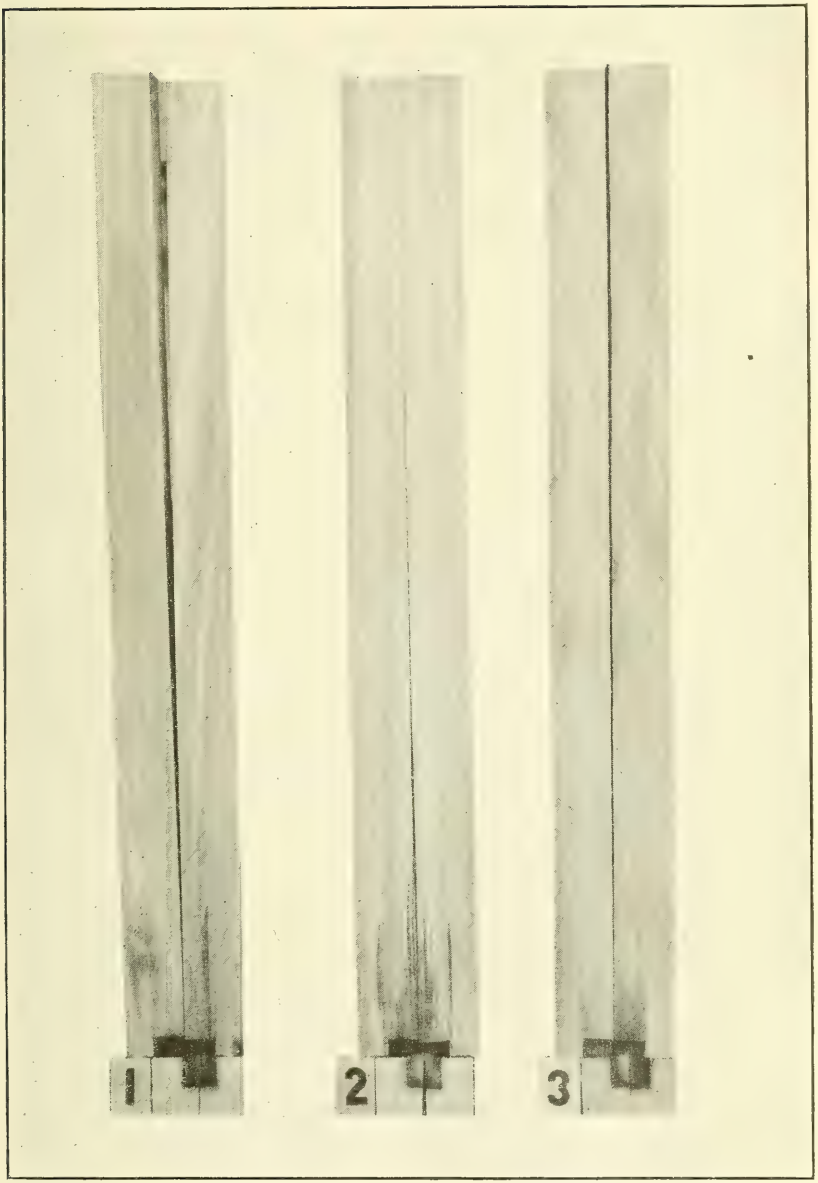
PENETRATION IN WHITE-HEART BEECH—HEARTWOOD (FAGUS ATROPUNICEA).

1, piece No. 86 treated 30 minutes; 2, piece No. 87 treated 60 minutes; 3, piece No. 88 treated 120 minutes. Compare the penetration of white-heart beech with that of red-heart beach, Plate XII.



PENETRATION IN HICKORY HEARTWOOD (HICORIA ALBA).

1, piece No. 69 treated 30 minutes; 2, piece No. 70 treated 60 minutes; 3, piece No. 71 treated 120 minutes. Note the uniform penetration in wood even at a considerable distance from the part where creosote was applied.

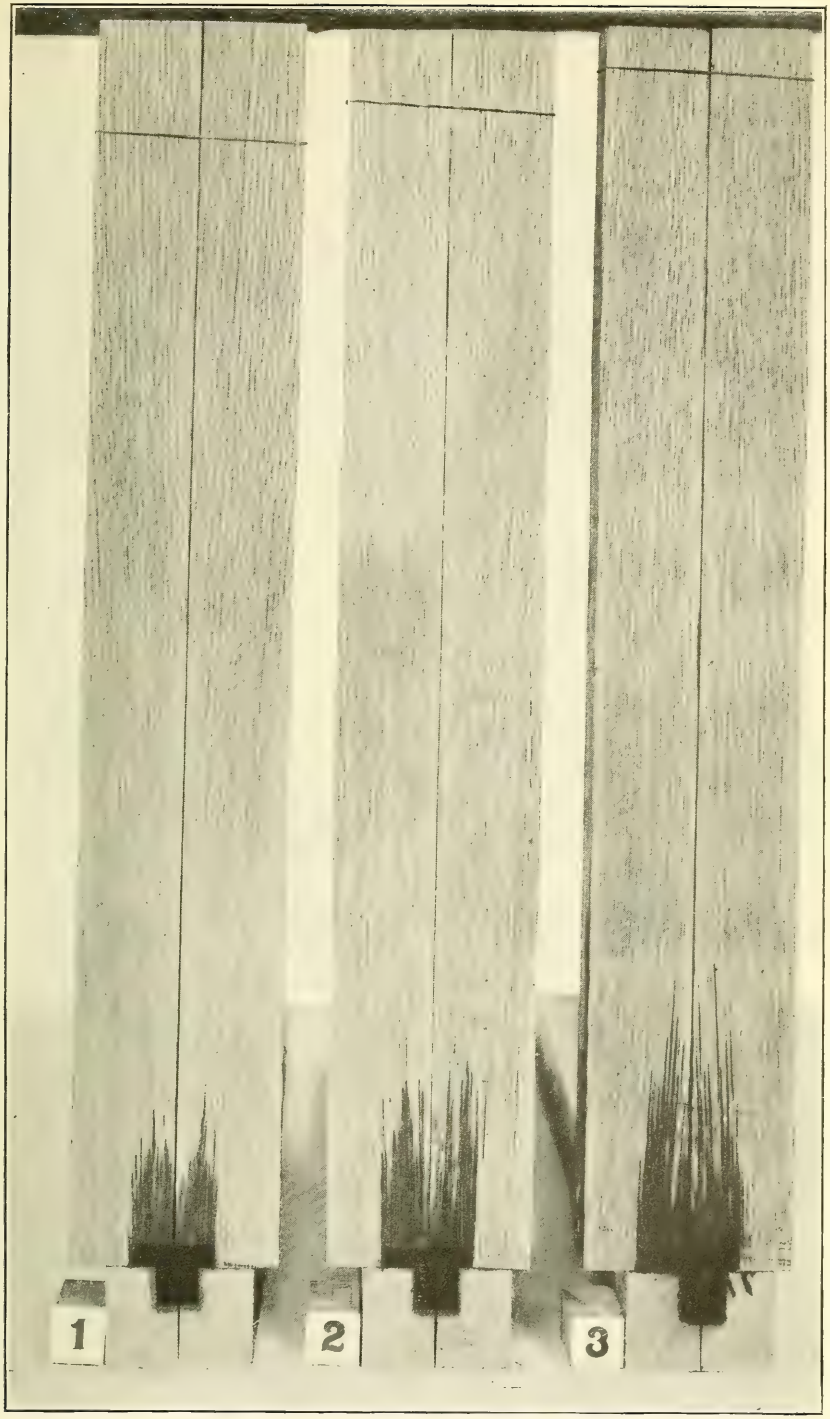


PENETRATION IN RED GUM—HEARTWOOD.

1, treated 30 minutes; 2, treated 60 minutes; 3, treated 120 minutes. The numerous tyloses and the infiltrating substances in the cell walls greatly retarded penetration.

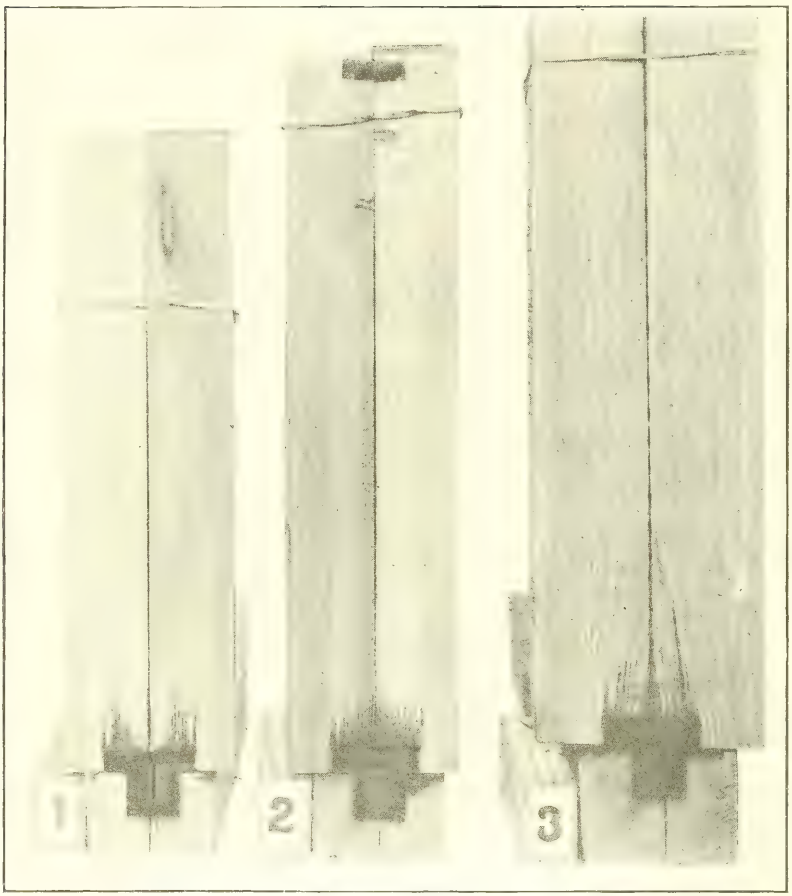
PENETRATION IN LARGETOOTH ASPEN—HEARTWOOD (POPULUS GRANDIDENTATA).

1, piece No. 45 treated 30 minutes; 2, piece No. 46 treated 60 minutes; 3, piece No. 47 treated 120 minutes. Largetooth aspen showed very erratic penetration, which is well illustrated in the three specimens shown.



PENETRATION IN WHITE OAK—HEARTWOOD (QUERCUS ALBA).

1, piece No. 77 treated 30 minutes; 2, piece No. 78 treated 60 minutes; 3, piece No. 79 treated 120 minutes.



PENETRATION IN RED-HEART BEECH (FAGUS ATROPUNICEA).

1, piece No. 89 treated 30 minutes; 2, piece No. 90 treated 60 minutes; 3, piece No. 91 treated 120 minutes. Compare the penetration in this wood with that shown in Plate VII, showing the penetration in white-heart beech.

FACTORS AFFECTING PENETRATION.

The penetrability of wood is greatly influenced by many factors not studied in these tests. Trees of the same species grown in different localities may differ greatly in their properties, hence the natural variability of the wood may largely influence penetration. The character of the penetration is an important factor. So also is the moisture content of the wood. Timber which has just been cut and which is, therefore, in the green condition is, as a rule, very much more resistant to treatment than that which has had the moisture removed. The method of seasoning the timber may also have an important bearing on the resulting penetration and absorption of preservative. Thus, wood which has been air seasoned may give quite different results from that which has been artificially seasoned either by steaming, boiling in oil, or by other processes.

In order to eliminate, so far as possible, variations arising from differences in moisture, the specimens used in the tests were dried to a low moisture content, although it is recognized that this is not done in commercial work where the methods of seasoning may vary greatly with different species of wood. Furthermore, sapwood and heartwood specimens were treated separately, although in commercial work timber under treatment may contain both heartwood and sapwood in widely varying proportions.

It was not within the scope of this work to study each species separately under the conditions most suitable for its treatment. The study was confined to one tree of each species. The trees were selected to be as nearly representative as possible, and all specimens used were closely matched. Since identical treatments were given to each species, it is possible to compare the penetrations and absorptions in the various species when tested under the same conditions.

EFFECT OF STRUCTURE ON PENETRANCE.

PORES OR VESSELS.

The pores or vessels, which serve to furnish a channel for the passage of sap from the roots of the tree to the leaves, are a very important factor in penetration with wood preservatives, especially when they are open passages through the wood.

1. Pores open.—In red oak, Plates II and III, the pores or vessels (V) are open passages. It is even possible to blow air through sticks of red oak several feet long. In a diffuse-porous wood they are more numerous but of smaller diameter. When the pores are open as in red oak or basswood, they are the main factor in the initial penetrance of the wood.

2. Pores closed by tyloses or gums.—When the pores or vessels are closed with tyloses, as in the post oak,[1] Plate IV, or with gummy substances, the relations are more complicated. Tyloses, if strongly developed, grow together and practically fill the vessel cavities, thus stopping the penetration through these elements. Creosote may be absorbed and stain the walls for a very short distance, but the main lines for liquid transfer are blocked. Various effects are produced by tyloses and gums according as these are more or less developed in different species. If the tyloses which grow out from different points on the walls of the pores or vessels do not meet and grow together, or if they are weak and readily broken down, they do not effectively check penetrance, as, for example, in chestnut and green ash. If they do not occur in all the vessels but only here and there, as in some diffuse-porous woods, their effect is, in general, proportional to their occurrence.

ARRANGEMENT OF THE PORES—RING-POROUS AND DIFFUSE-POROUS WOODS.

A much greater variation in penetration was found in the diffuse-porous than in the ring-porous species. In diffuse-porous woods tyloses were not so uniformly distributed, which resulted in erratic or irregular penetrations. Diffuse-porous woods also showed considerable variation, due to gums, infiltrating substances, and cross-grained structure. Examples of species exhibiting these variable characteristics are silver maple, sycamore, sugar maple, largetooth aspen, and red gum.

WOOD PROSENCHYMA (FIBERS AND TRACHEIDS).

When the pores or vessels of a wood are closed by tyloses or gums, penetration of the wood prosenchyma may become of primary importance. The cells of this tissue have closed ends. Liquids in passing from cell to cell must then filter through the wall itself or through the thin places or pits in the cell wall. The pits are poorly developed or practically lacking in some hardwood prosenchyma. It is therefore apparent that penetrance in this tissue can not take place so rapidly nor extend so easily for long distances as it can in the pores or vessels. (In Plates I, II, III, and IV this tissue is indicated by "X.") Nevertheless, the wood prosenchyma is of considerable importance in relation to the penetrance and absorption obtained for certain woods. Hickory is a particularly good example of a wood where penetrance takes place chiefly in the wood prosenchyma.

THE MEDULLARY RAYS AND WOOD PARENCHYMA.

The medullary rays and other parenchyma cells appeared to be of little practical importance in the penetration of the hardwoods with

[1] This species is similar in structure to white oak.

creosote. In oak, hickory, and sycamore, for example, the rays were conspicuous because of their resistance to penetration in marked contrast to the surrounding treated tissue.

SPRINGWOOD AND SUMMERWOOD.

In the hardwoods the effect of springwood or summerwood on treatment was not so important as the effect of the peculiarities of the different types of structure and the arrangement of the elements, such as vessels, fibers, rays, etc. In very heavy treatments the creosote not only passed through the cavities or lumena of the cells in both spring and summer wood, but sometimes penetrated the walls.

CONDITION OF GRAIN.

More or less difficulty was experienced in treating the woods in which the fibers were interlaced or cross-grained.

DENSITY.

The ease or difficulty of securing a satisfactory penetration does not appear to depend upon the density. Woods having high specific gravities were sometimes treated with greater ease than species of much lower specific gravity, and vice versa.

RADIAL, TANGENTIAL, AND LONGITUDINAL PENETRATION.

In most of the species tested the radial and tangential penetrations were very much less than the longitudinal penetration. In general, the species that were difficult to treat showed less difference than those which were easy to treat.

GROUPING OF SPECIES.

GROUPING WITH RESPECT TO PENETRATIONS AND ABSORPTIONS.

Table 2 (see Appendix) gives the average longitudinal and radial penetrations obtained in the penetrance tests, and the average absorptions of the specimens treated in the cylinder. In this table and in the diagram, figure 3, the species are arranged in order of increasing absorptions in the impregnation test. In figure 3 are also shown the corresponding average longitudinal and radial penetrations. While the longitudinal penetrations show a general tendency to increase as the absorptions increase, there is nevertheless a considerable variation. The radial penetrations were very small in most of the woods treated and do not seem to bear an important relation to the absorptions. In some cases it is possible that the longitudinal penetrations would have shown a closer relation to the absorptions if the average had been based on the same number of specimens in both series of tests. The penetrations represent the

average of three specimens of each species treated in the penetrance apparatus, and the absorptions are the average of seven specimens treated in the cylinder. However, a close relation between penetration and absorption could not be expected in many of the species. For example, species such as red oak and chestnut oak have large open pores or vessels which allow the preservative to pass easily from one end of the stick to the other. The wood prosenchyma of these species is very difficult to penetrate and treatment results mainly in coating the vessel walls with the preservative and not in

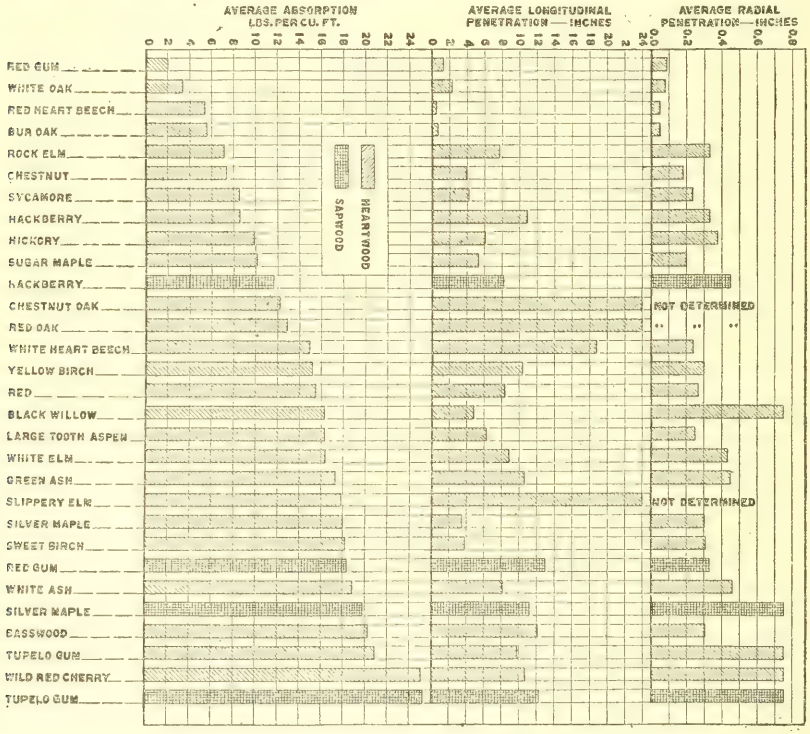


FIG. 3.—Comparative absorptions and penetrations.

a complete impregnation of the wood substance. Slippery elm has large open vessels similar to those of red oak and chestnut oak, but in this case the wood prosenchyma readily absorbs the preservative. It was therefore possible to secure both a complete penetration and a fairly heavy absorption in this wood. In hickory, the large vessels are almost completely closed by tyloses, but a fairly good penetration was obtained on account of the comparative ease with which the wood prosenchyma absorbed creosote. Species in which the tyloses are more or less irregularly distributed, such as black willow and large-

tooth aspen, naturally show less uniformity in the relation between penetration and absorption. A more constant relation between these factors is evident in species, such as basswood and tupelo gum, which take treatment both in vessels and in the wood substance.

Detailed results of the tests and data on each species are given in the Appendix.

GROUPING OF HARDWOODS FOR TREATMENT.

A classification of the species studied in this investigation into three groups according to the ease or difficulty of penetration has been attempted. This classification is based on the results obtained in the penetrance and cylinder tests and upon the structural characteristics as determined by a microscopic examination, and is intended only as an aid in the commercial grouping of such woods for treatment. The heartwood and sapwood are here considered separately, but in commercial treating plant operations the same stick often contains both; so the groups which are given may not be the ones which must be used in practice. For example, tupelo gum and red oak ties, both classed as easily treatable species, are not grouped together during treatment because the tupelo gum usually contains more sapwood.

Any grouping of species for preservative treatment must be a somewhat arbitrary classification. It is difficult to determine where the line should be drawn separating species of one group from those of another. However, when the classifications are taken as a whole there is a very distinct difference in the ease or difficulty with which the species of one group took treatment as compared with those of another group. Furthermore, the results obtained in the penetrance and absorption experiments correspond quite well in most cases with what would be expected from the structure of the various species. The grouping effected may be useful in giving an idea of what to expect of species unfamiliar to the reader, in comparison with species with which he is familiar.

GROUP I.

(Woods which treated easily in the tests.)

Ring-porous woods:

Tyloses generally lacking—

- Slippery elm—*Ulmus pubescens*, heartwood.
- Red oak—*Quercus rubra*, heartwood.
- Chestnut oak—*Quercus prinus*, heartwood.

Tyloses scatteringly developed or thin walled—

- White ash—*Fraxinus americana*, heartwood.
- Green ash—*Fraxinus lanceolata*, heartwood.
- White elm—*Ulmus americana*, heartwood.
- Hackberry—*Celtis occidentalis*, sapwood.

Diffuse-porous woods:
Tyloses generally lacking—
Tupelo gum——*Nyssa sp.*, sapwood.
Wild red cherry——*Prunus pennsylvanica*, heartwood.
Tupelo gum——*Nyssa sp.*, heartwood.
Basswood——*Tilia americana*, heartwood.
Silver maple——*Acer saccharinum*, sapwood.
Tyloses scatteringly developed—
Red gum——*Liquidambar styraciflua*, sapwood.
Tyloses not present—
Yellow birch——*Betula lutea*, heartwood.
Sweet birch——*Betula lenta*, heartwood.
Red birch——*Betula nigra*, heartwood.
White-heart beech——*Fagus atropunicea*, heartwood.

GROUP II.

(Woods which were moderately difficult to treat in the tests.)

Ring-porous woods:
Tyloses present—
Mockernut[1] hickory——*Hicoria alba*, heartwood.
Hackberry——*Celtis occidentalis*, heartwood.
Rock elm——*Ulmus racemosa*, heartwood.
Chestnut——*Castanea dentata*, heartwood.
Diffuse-porous woods:
Tyloses present—
Black[2] willow——*Salix nigra*, heartwood.
Largetooth aspen——*Populus grandidentata*, heartwood.
Sycamore——*Platanus occidentalis*, heartwood.
Tyloses not present—
Sugar maple——*Acer saccharum*, heartwood.
Silver maple——*Acer saccharinum*, heartwood.

GROUP III.

(Woods which were very difficult to treat in the tests.)

Ring-porous woods:
Tyloses present—
Bur oak——*Quercus macrocarpa*, heartwood.
White oak——*Quercus alba*, heartwood.
Diffuse-porous woods:
Tyloses present—
Red-heart beech——*Fagus atropunicea*, heartwood.
Red gum——*Liquidambar styraciflua*, heartwood.

Group I.—All the specimens of Group I treated in the cylinder experiments were completely penetrated at 100 pounds pressure per square inch. An average absorption of more than 12 pounds per cubic foot was obtained in the cylinder treatment, and an average longitudinal penetration of over 8 inches was obtained in the penetrance experiments, with the exception of two species, hackberry, which received slightly less than 12 pounds of oil, and sweet birch, which received only 3.85 inches of longitudinal penetration. The low longitudinal penetration in sweet birch was due to crooked grain, the oil

[1] Hickory might be placed in Group I, as it showed good penetrations. The reason for placing it in Group II was that the absorptions were not so heavy as those obtained in the species given in Group I.

[2] Black willow specimens treated in the cylinder showed good absorptions and penetrations. Specimens treated in the penetrance apparatus did not show very extensive longitudinal penetration. This species is put in Group II rather than in Group I, as it is known to respond to treatment in a manner similar to large-tooth aspen, which in many cases is quite variable, partly on account of the irregular distribution of tyloses.

coming out at the side of the specimens instead of passing through to the end.

The pressure and time of treatment are not comparable to commercial treating-plant conditions because of the size and dry condition of the specimens.

The woods included in Group I were all comparatively free from tyloses and other obstructions in the vessels. Wood gums were present to only a slight extent; for example, in birch and maple. All of the species included in this group therefore treated very easily. Examples of species which exhibit very clearly the characteristic open structure are red oak, chestnut oak, and slippery elm. The wood prosenchyma, or fibrous part of the wood substance, was also usually well treated in woods of this group. The medullary rays and other parenchyma cells received, as a rule, little treatment, although exceptions were noted in woods like ash and birch where creosote also penetrated this part of the wood structure.

While numerous tyloses were found in the ashes, their influence on penetration of these species was not so important as in most of the other species in which tyloses were present. This was due to the fact that the tyloses were not fully developed in the vessels, and that they were also very often thin-walled and somewhat variable.

Group II.—With the exception of hickory, the species in Group II showed incomplete and variable penetrations in all of the cylinder treatments. The average absorptions obtained in these treatments were between 7 and 10 pounds per cubic foot in all of the species except silver maple, black willow, and largetooth aspen. In these three woods the absorptions were somewhat higher, but in the individual specimens they were extremely variable and the penetrations were very irregular on account of the uneven distribution of gummy substances in the maple and tyloses in the other two species. In all of the species of this group the average longitudinal penetrations obtained in the penetrance tests were between 4 and 8 inches.

Tyloses were present in all the species in this group except the two maples, but with few exceptions they did not completely close the vessels. Hickory was one of the few cases in which it was possible to obtain a fairly good penetration, although the pores were completely blocked with tyloses. In this species the treatment took place through the wood prosenchyma, which was quite permeable.

Group III.—The average absorptions in the cylinder experiments were less than 6 pounds per cubic foot, and the average longitudinal penetrations obtained in the penetrance tests were less than $2\frac{1}{2}$ inches in all of the species classed in Group III. In most of these species the vessels were, as a rule, completely closed by an abundant growth of tyloses, which effectively retarded the entrance of creosote. The wood prosenchyma of these species was also very difficult to treat,

possibly because of the presence of infiltrated substances. The medullary rays were practically unpenetrated. Heartwood specimens treated in the cylinder rarely showed any more than a very slight end penetration.

RELATION OF GROUPING TO COMMERCIAL TREATMENT.

The form in which a timber is treated determines to a large extent the relative importance of securing a penetration in the sapwood or in the heartwood. Penetration of the sapwood is of principal importance in the treatment of material in round forms, such as posts and telephone poles, as in this case it is the sapwood that is exposed to the attack of fungi. Although tests could not be made on sapwood from each of the species used, the sapwood of practically all of these woods is known to be fairly easy to penetrate in both longitudinal and radial directions. Even those species which were most difficult to penetrate in the heartwood took treatment comparatively well in the sapwood.

In the treatment of sawed or split timbers, which generally have little or no sapwood, the penetration of the heartwood becomes of chief importance. The results of the experiments indicate that woods in Group I are well adapted for treatment in dimension form, since the heartwood as well as the sapwood of the species was penetrated with comparative ease. Where radial penetration of the heartwood is of special importance, as in the open-tank treatment of split timbers for fence posts, particular attention should be given to the ease or difficulty with which the wood prosenchyma can be penetrated.

The heartwood of some of the woods in Group II would probably be somewhat difficult to penetrate thoroughly and evenly in pressure treatments. This difficulty would be more apparent in the timbers of larger size, such as railroad ties, mine timbers, etc. With one or two exceptions, hickory, for example, radial penetration was small in species of this group. The heartwood of the species given in Group III would appear to be difficult to treat. Specimens of this group treated in the penetrance apparatus and in the cylinder showed no appreciable radial penetration, and only a slight longitudinal penetration at the ends.

CONCLUSIONS.

There are several very important factors other than the wood structure which, in commercial work, influence the absorption and penetration of preservative. Some of these are the natural variability of the wood, even in the same species, the moisture content when treated, the method of seasoning and treatment adopted, and the character of the preservative used. In order to study the true effects of the

various elements of wood structure on the penetration of creosote, it was necessary, so far as possible, to eliminate these other factors. The following conclusions, which are based only on structural considerations, should not be applied to commercial practice, such as the grouping of timber for treatment,[1] without considering the other factors that are involved.

1. The most important of the structural factors affecting the penetration of the hardwoods is the condition of the vessels in the wood. When the vessels are open, it is comparatively easy to secure a good penetration. If the vessels are closed by tyloses or gummy substances, they are usually rendered more or less impermeable to creosote.

2. Next in importance is the ability of the wood prosenchyma (fibers, etc.) to absorb creosote. In some species having numerous and well-developed tyloses in the pores (hickory, for example), it was found possible to obtain a deep penetration on account of the comparative ease with which the wood prosenchyma could be treated. The penetrability of this part of the wood structure is therefore of great importance in species having the vessels closed by tyloses or other material. The wood prosenchyma in the sapwood took treatment much more easily than that in the heartwood, probably because the heartwood contained infiltrating substances in the cell walls which tended to make the wood substance less permeable. Woods which were penetrated in both the vessels and wood prosenchyma generally showed the heavier absorption and deeper penetration. Those species which took very irregular absorptions in the cylinder tests were found to possess unusual structural characteristics, such as an irregular distribution of tyloses, interlaced fibers, or cross-grained structure.

The experiments indicate that even in species of very similar structure the manner of taking treatment may vary widely. This is illustrated in the treatment of hickory and white oak. Both of these woods are ring-porous and the vessels are closed by abundant tyloses. Hickory, however, took a fairly good treatment, whereas white oak was practically impermeable. The variation in the permeability of red heart and white heart beech is also an example of the different manner in which woods of similar structure may take treatment.

3. Penetration and absorption of the preservative is much less uniform in woods of the diffuse-porous group than in the ring-porous, probably because the tyloses in the vessels, and the gums and infiltrating substances are less uniformly distributed in diffuse-porous woods. In most of the species treated little or no penetration of the preservative occurred in the medullary rays and other parenchyma cells.

[1] Some of the other factors affecting the treatment of wood are taken up in Forest Service Bulletin 118, "Prolonging the Life of Crossties."

APPENDIX.

CHARACTERISTICS OF THE VARIOUS SPECIES AND RESULTS OF TREATMENT.[1]

Ash, green (*Fraxinus lanceolata*)—*heartwood.*—Thin-walled tyloses were present in both sapwood and heartwood of green ash. Very little difficulty was experienced in obtaining a fairly good penetration in both the penetrance and cylinder treatments. Complete penetration resulted in the cylinder treatments when pressures of 75 pounds or more were employed. The wood prosenchyma was penetrated, and also the vessels and tyloses to some extent.

Ash, white (*Fraxinus americana*)—*heartwood.*—Thin-walled tyloses are scattered through both sapwood and heartwood of white ash. The wood took treatment fairly easily, good penetrations being obtained both in the penetrance and impregnation tests. Both the vessels containing tyloses and the wood prosenchyma were penetrated to some extent. Creosote was found distributed chiefly throughout the wood prosenchyma. Although this species has numerous tyloses, they are thin-walled. In all probability many of the vessels are not entirely closed by them, which allows the creosote to enter the pores and give fairly good penetrations.

Aspen, largetooth (*Populus grandidentata*)—*heartwood.*—Largetooth aspen is a close-grained, diffuse-porous wood with small pores. Both heartwood and sapwood contain scattered tyloses. Specimens treated in both the penetrance apparatus and in the cylinder showed quite variable penetrations. In all tests the penetrations were largely in streaks and in most cases entered the wood but a short distance. Some of the specimens were fairly well treated throughout their volume and others were only slightly penetrated. This variable penetration was very likely due to an unequal distribution of tyloses throughout the specimens, for the tyloses were found to be more numerous in the untreated portions. The preservative was found mainly in the vessels of the wood and to some extent in the prosenchyma.

Basswood (*Tilia americana*)—*heartwood.*—Basswood contains no tyloses in either the heartwood or sapwood. The specimens were easily treated in the penetrance apparatus and in the cylinder. Both the vessels and wood prosenchyma were quite thoroughly penetrated. Good penetrations were secured in the cylinder treatments, even at low pressures.

Beech, white-heart (*Fagus atropunicea*).—Tyloses are rarely found in either the heartwood or sapwood of white-heart beech. Creosote

[1] In some cases general remarks on the characteristics of the species were supplemented from the descriptions given in Snow's "Principal Species of Woods."

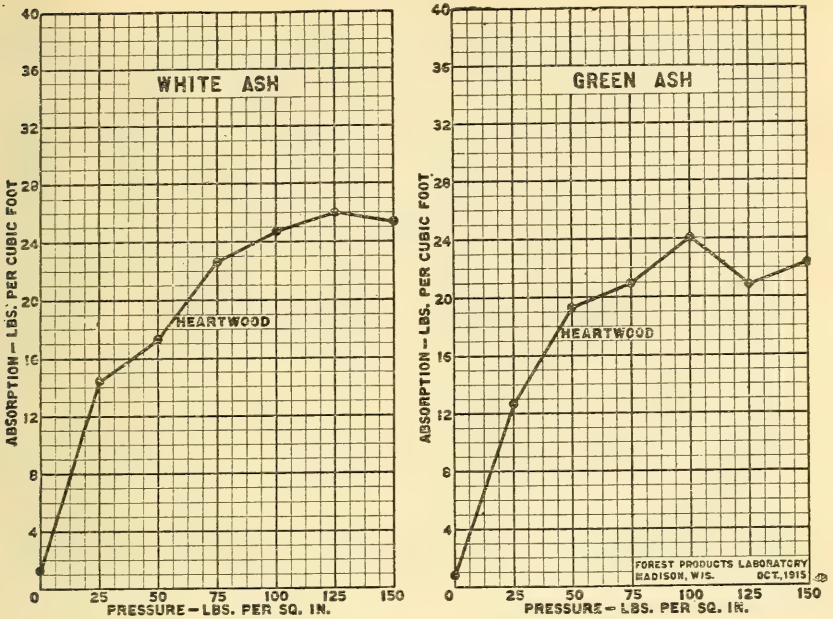


FIG. 4.—Absorption in the heartwood of white ash and green ash.

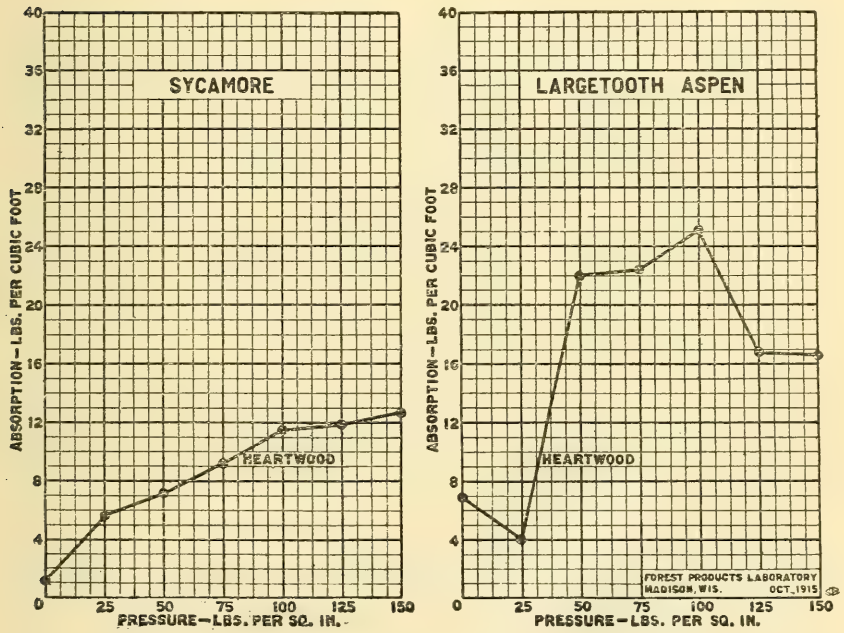


FIG. 5.—Absorption in the heartwood of sycamore and largetooth aspen.

penetrated the wood very readily both in the penetrance and cylinder treatments. The penetrance was especially uniform in this species and the oil apparently reached all parts of the wood structure.

Beech, red-heart (*Fagus atropunicea*).—Red-heart beech contains numerous tyloses in the heartwood and few in the sapwood. This wood was found to be very difficult to penetrate. Specimens treated in the cylinder showed only a very limited end penetration. A very small amount of creosote was found in the vessels and little or none in the wood prosenchyma. The difficulty of penetration seems to have been caused by the abundant tyloses found in the pores of the wood and by the infiltrating substances in the fiber walls of the "red heart" portion, which apparently prevented penetration in these elements.

Birch, sweet (*Betula lenta*)—*heartwood.*—The fibers in sweet birch are thick-walled, and gummy substances are frequently found in the wood. Tyloses are not found in either sapwood or heartwood. Specimens treated in the cylinder were well penetrated even at low pressures. Penetration was found to be well distributed throughout the wood structure. The wood prosenchyma was fairly well penetrated, but creosote was present to a greater extent in the vessels.

Birch, yellow (*Betula lutea*)—*heartwood.*—Yellow birch contains no tyloses in either sapwood or heartwood. The pores were very easily penetrated in all of the tests. In the penetrance tests the preservative penetrated to the ends of the sticks almost immediately after pressure was applied. In the cylinder treatments the vessels were easily penetrated when the wood was merely immersed in the preservative for an hour. When pressure was applied both the vessels and wood prosenchyma were thoroughly treated.

Birch, red (*Betula nigra*)—*heartwood.*—The pores in red birch are somewhat larger than those in sweet birch. The wood fibers are fairly thin-walled and there are no tyloses in sapwood or heartwood. As in yellow birch, the vessels were rather easily penetrated at low pressures. At pressures of 50 pounds or more both the vessels and wood prosenchyma were well penetrated.

Cherry, wild red (*Prunus pennsylvanica*)—*heartwood.*—Wild red cherry does not contain tyloses. The wood was treated very easily and was found to be fairly well penetrated when merely immersed in the preservative for an hour. Penetration was complete in practically all of the treatments made.

Chestnut (*Castanea dentata*)—*heartwood.*—The pores in chestnut are numerous and are more or less filled with tyloses in both sapwood and heartwood. This species was very difficult to penetrate both in the penetrance apparatus and in the cylinder. Specimens treated in the cylinder showed very little radial or tangential penetration. The tyloses appeared to close the vessels, so that only a very limited pene-

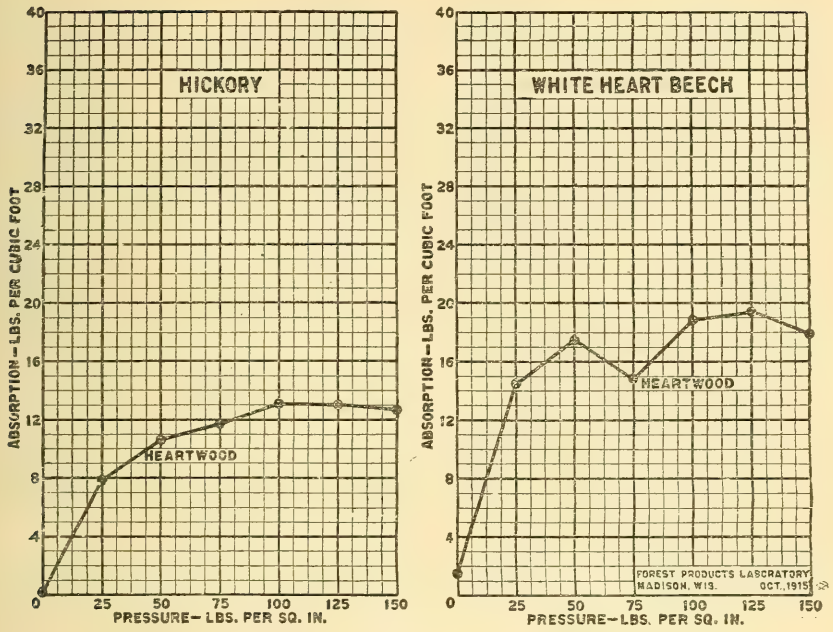


FIG. 6.—Absorption in the heartwood of hickory and white-heart beech.

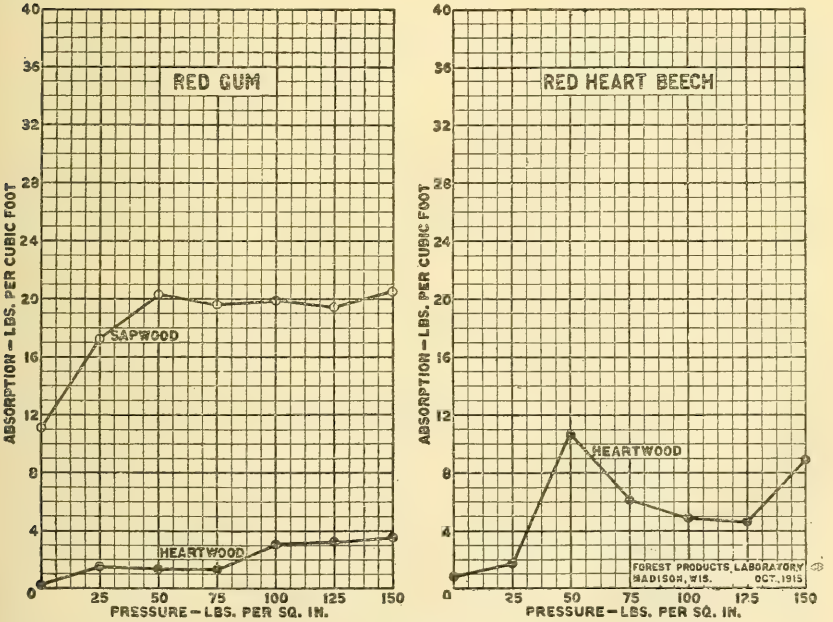


FIG. 7.—Absorption in the heartwood of red gum and red-heart beech and the sapwood of red gum.

tration could be obtained at any of the pressures used. Creosote was found chiefly in the vessels and very little in the wood prosenchyma or medullary rays.

Elm, rock (*Ulmus racemosa*)—*heartwood.*—Rock elm is a ring-porous wood with interlaced fibers. Tyloses were generally few and scattered in the specimens treated. All of the specimens tested in both the penetrance apparatus and in the cylinder showed erratic penetrations. In most cases penetration took place in streaks, some of the wood being well penetrated and other parts entirely untouched. Specimens treated in the cylinder at the lower pressures showed a better absorption and penetration than specimens treated at the higher pressures. This may have been due to an irregular distribution of tyloses in the specimens. The difficulty with which this wood takes treatment seems to indicate that the interlaced condition of the wood fibers may vary throughout the stick, thereby causing irregular penetrations. Most of the preservative was found to be in the vessels. There was very slight penetration in the wood prosenchyma and medullary rays.

Elm, slippery (*Ulmus pubescens*)—*heartwood.*—There are practically no tyloses present in either sapwood or heartwood of slippery elm. On account of the open condition of the large and numerous pores, it was not possible to make any tests in the penetrance apparatus. The creosote penetrated the wood largely through the vessels, but also to some extent in the wood prosenchyma. Good penetrations were easily secured on account of the large open pores.

Elm, white (*Ulmus americana*)—*heartwood.*—Tyloses were few and scattered in the specimens of white elm tested, and the penetration was chiefly in the vessels. The medullary rays and wood prosenchyma had only a slight penetration. Specimens treated in the cylinder showed good penetrations with most of the pressures employed. Fairly good penetrations were also secured in the penetrance apparatus.

Gum, red (*Liquidambar styraciflua*)—*heartwood and sapwood.*—Red gum is rather heavy, moderately hard, and cross-grained. The fibers generally have thick walls and are arranged in definite radial rows. The species is diffuse-porous with pores numerous and uniformly distributed. Tyloses are usually present and scattered in both heartwood and sapwood. Infiltrating substances are present to a large extent in the cell walls. It was difficult to secure an appreciable penetration of the heartwood in any of the treatments. Specimens treated in the cylinder showed practically no radial or tangential penetration. The difficulty in treating this wood was very likely due in a large degree to the infiltrating substances in the cell walls, as well as tyloses, which prevented the preservative from entering the vessels in which they were well developed. The cross-grained structure and thick walls of the fibers may also have been factors influenc-

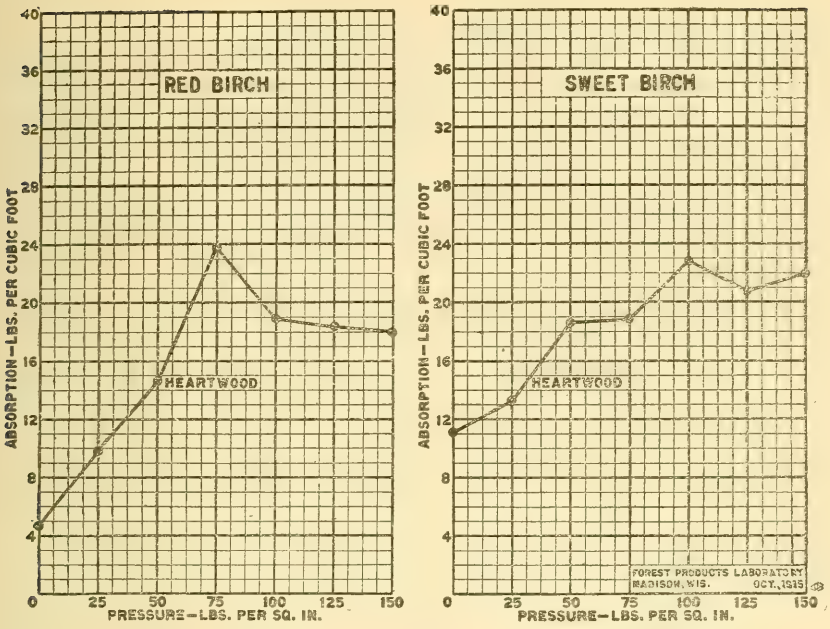


FIG. 8.—Absorption in the heartwood of red birch and sweet birch.

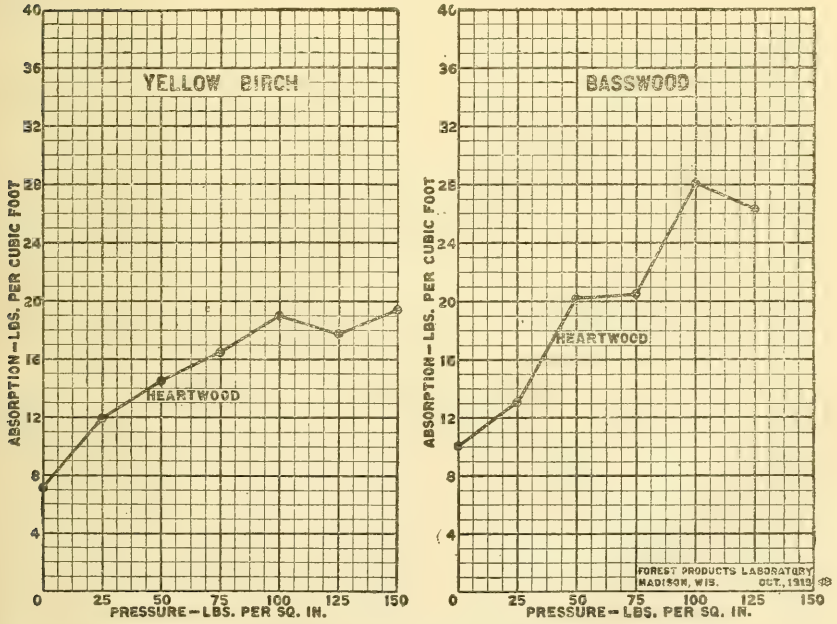


FIG. 9.—Absorption in the heartwood of yellow birch and basswood.

ing the absorption and penetration to some extent. The sapwood was very easily treated even at low pressures.

Gum, tupelo (Nyssa, sp.)—heartwood and sapwood.—In tupelo gum the pores are numerous, of medium size, and usually evenly distributed. No tyloses were found in the species treated. On account of the numerous vessels and penetrable structure of the fiber walls, good penetrations were obtained. Both the heartwood and sapwood treated very easily even at low pressure. Sapwood specimens were well penetrated when immersed for an hour in the preservative without pressure.

Hackberry (Celtis occidentalis)—heartwood and sapwood.—Tyloses occurred irregularly in both heartwood and sapwood of hackberry. The penetration occurred mainly in the vessels and wood prosenchyma and to a small extent in the medullary rays. The sapwood was fairly easily penetrated even at low pressures, particularly in the summerwood. With the higher pressures used in the cylinder treatments, both springwood and summerwood were well penetrated. The heartwood showed an irregular penetration in all of the cylinder treatments, due, in part, to the abundant tyloses in the vessels of the untreated portions. The springwood was found to be much more difficult to treat than the summerwood because many well developed tyloses closed the large springwood vessels.

Hickory, mockernut (Hicoria alba)—heartwood.—Hickory is a ring-porous wood, in which the fibers are relatively thick-walled and tyloses are generally abundant in both sapwood and heartwood. All the specimens showed a fairly uniform penetration, and those treated in the cylinder were well penetrated when pressures of 50 pounds or more were employed. Creosote was found to have penetrated mainly in the wood prosenchyma, and there was little or no penetration in the vessels or in the medullary rays. It is probable that the abundance of tyloses in the vessels effectively closed them against the entrance of the preservative. Penetration in this species would, therefore, seem to be dependent on the ease with which the wood prosenchyma can be treated. In even the most thoroughly penetrated specimens the tyloses remain uncolored, indicating that in this wood these growths were practically impermeable to creosote.

Maple, silver (Acer saccharinum)—heartwood and sapwood.—Silver maple is a diffuse-porous wood. No tyloses were present in the specimens treated. Both the sapwood and heartwood were found to be fairly easy to treat, but more variation in penetration was found in the heartwood specimens. At low pressures the heartwood showed a mottled or streaked appearance, probably due to the presence of gums. A good penetration was secured in the sapwood at pressures over 25 pounds per square inch. Penetration took place mainly in the vessels and wood prosenchyma and was very slight in the medullary rays.

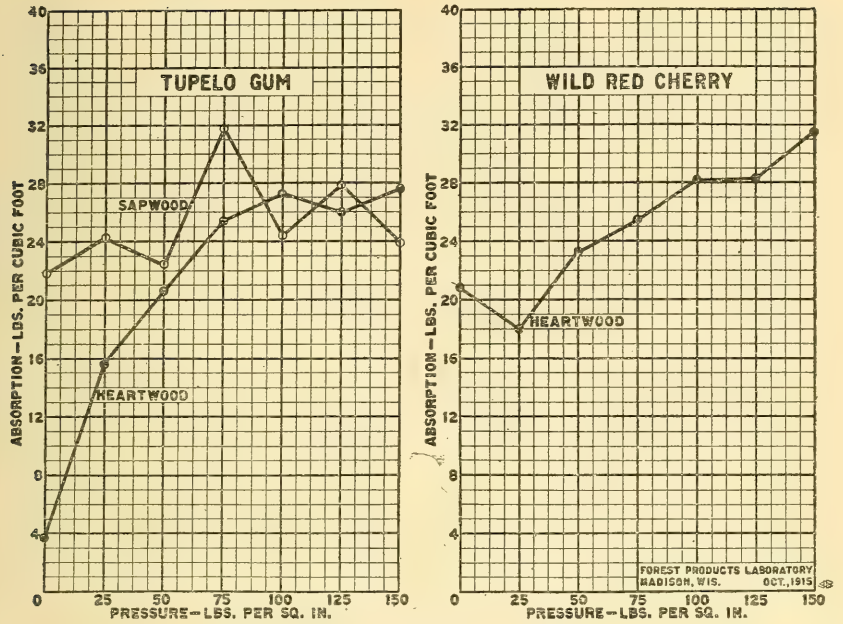


FIG. 10.—Absorption in the heartwood of wild red cherry and in the heartwood and sapwood of tupelo gum.

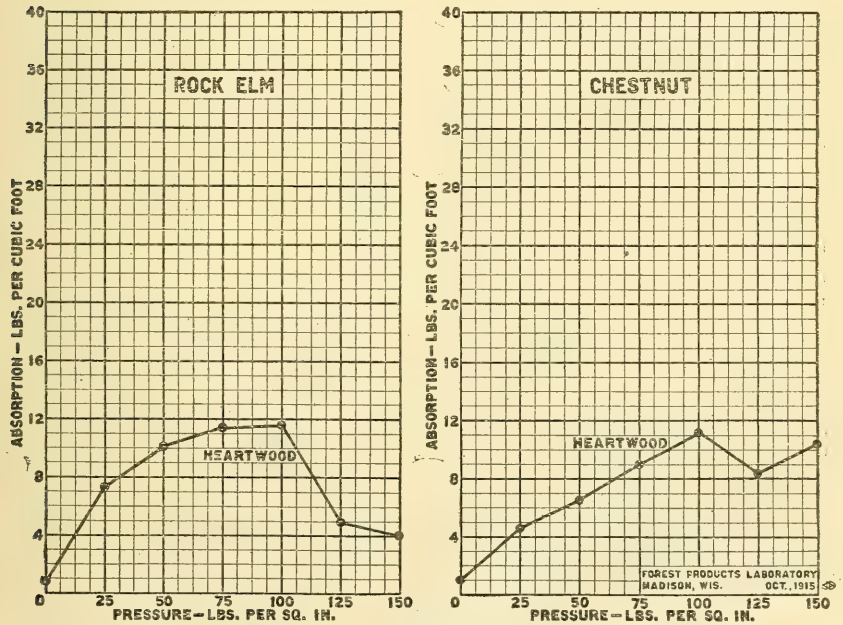


FIG. 11.—Absorption in the heartwood of rock elm and chestnut.

Maple, sugar (*Acer saccharum*)—*heartwood.*—Sugar maple is a diffuse-porous wood. In the specimens tested tyloses were not present in either sapwood or heartwood, but gums and infiltrating substances were present. The specimens showed a more or less variable penetration. In the cylinder treatments some of the pieces were well penetrated and others were penetrated but a short distance or in streaks. Creosote penetrated chiefly in the wood prosenchyma, although it was also present to some extent in the vessels. The presence of gums seems to be responsible for the variable penetrations secured in the tests.

Oak, bur (*Quercus macrocarpa*).—Tyloses are numerous in both sapwood and heartwood of bur oak. The effect of tyloses on penetration is very marked in this species, and it was found to be almost impossible to penetrate the heartwood to an appreciable extent. Very little creosote was found in the vessels, which seemed to be effectively blocked by tyloses. Two or three of the specimens treated in the cylinder showed a fairly good penetration in part of the wood. The distinct demarcation of the treated and untreated areas seemed to indicate that the wood which was penetrated might have been sapwood not clearly distinguishable before treatment. The medullary rays were practically untreated in all of the tests.

Oak, chestnut (*Quercus prinus*)—*heartwood.*—The structure of chestnut oak is very similar to that of red oak, being ring-porous and generally without tyloses, although botanically chestnut oak is classed as a white oak. Penetrance tests could not be made on this species on account of the open condition of the vessels. Penetration took place mainly in the vessels or pores. The cell walls were practically unpenetrated by the preservative. Railroads have frequently classed this species with the white oaks and installed chestnut oak ties in the track without treatment. Since the wood takes treatment easily and the pores generally are without tyloses, chestnut oak ties should evidently be treated with a preservative.

Oak, red (*Quercus rubra*)—*heartwood.*—There are practically no tyloses in the vessels of red oak. On account of the very porous condition of the wood, penetrance tests could not be made. Specimens treated in the cylinder were penetrated largely in the vessels, but very little in the heartwood prosenchyma. The sapwood prosenchyma, however, is known to take treatment very easily.

Oak, white (*Quercus alba*)—*heartwood.*—The pores in both sapwood and heartwood of white oak are filled with tyloses. These tyloses and the character of the wood prosenchyma were an important factor in making it difficult to secure more than a very slight penetration in the specimens tested. Very little creosote was found in either the vessels or wood prosenchyma. The tyloses were found to be unpenetrated even in those portions of the wood which had been treated.

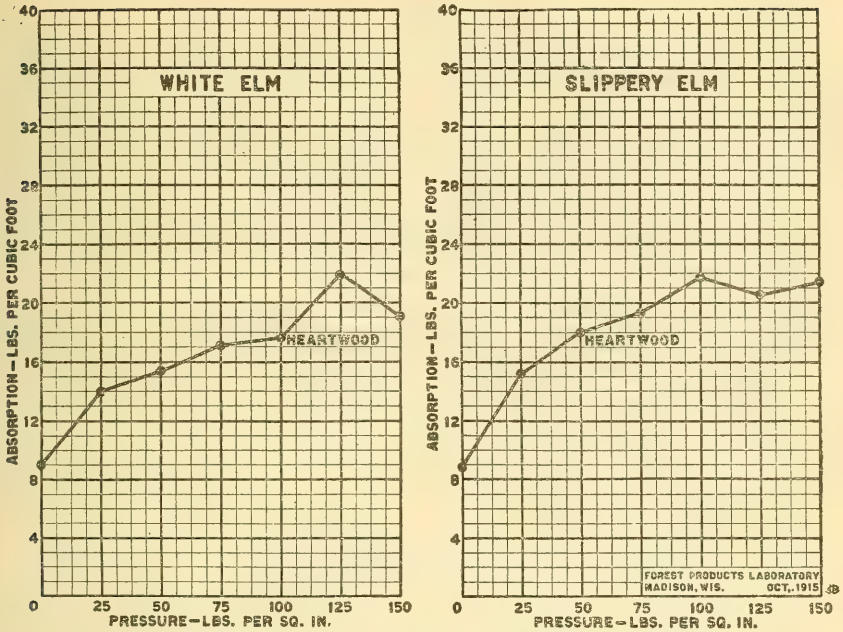


FIG. 12.—Absorption in the heartwood of white elm and slippery elm.

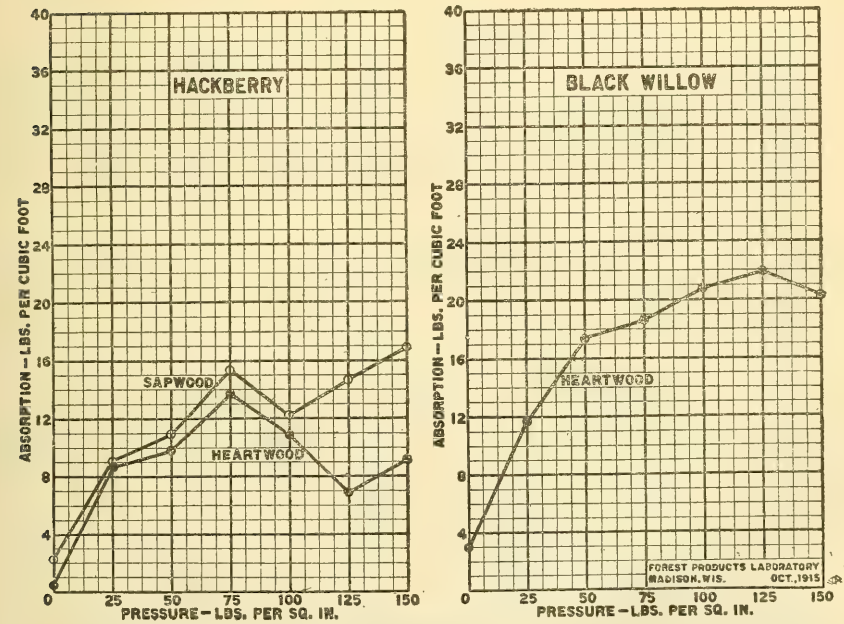


FIG. 13.—Absorption in the heartwood of hackberry and black willow and the sapwood of hackberry.

Sycamore (*Platanus occidentalis*).—Tyloses occurred scatteringly in the specimens of sycamore treated. Penetration was found to take place mainly through the vessels. Very little creosote was found in the wood prosenchyma or parenchyma. The wood was difficult to treat in either the penetrance apparatus or in the cylinder. Complete penetrations in the impregnation tests were not obtained, even at pressures of from 125 to 150 pounds per square inch. The difficulty in treating this species seems to be due largely to the tyloses and to the cross-grained structure of the wood.

Willow, black (*Salix nigra*)—*heartwood.*—Knots in the wood made it difficult to get good clear specimens of willow. Specimens treated in the cylinder showed fairly good penetrations for most of the pressures used. Tyloses are scattered in both sapwood and heartwood. The tyloses in the vessels did not prevent penetration. Creosote was found to be present to a considerable extent in both the vessels and the wood prosenchyma.

TABLE 2.—*Species in the order of amount of absorption,*[1] *and comparative longitudinal and radial penetration.*

Species.	Character of wood.	Impregnation tests.	Penetrance tests.				Average dry weight per cubic foot.
			Average time of treatment.	Time required to penetrate 24 inches.	Average longitudinal penetration.	Average radial penetration.	
		Lbs. per cu. ft.	*Minutes.*	*Minutes.*	*Inches.*	*Inches.*	*Pounds.*
1. Red gum	Heartwood	2.03	70		1.35	0.09	38.8
2. White oak	do	3.40	70		2.32	.08	45.3
3. Red-heart beech	do	5.39	70		.50	.05	40.8
4. Bur oak	do	5.57	70		.61	.05	40.8
5. Rock elm	do	7.18	70	2 to 5	7.66	.33	38.6
6. Chestnut	do	7.32	70		4.00	.18	25.4
7. Sycamore	do	8.48	70		4.17	.23	35.0
8. Hackberry	do	8.54	70		10.83	.33	38.2
9. Hickory, mockernut	do	9.86	70		6.06	.38	52.3
10. Sugar maple	do	10.09	45		5.33	.20	43.7
11. Hackberry	Sapwood	11.61	75	1	8.16	.45	35.8
12. Chestnut oak [2]	Heartwood	12.19					47.8
13. Red oak [2]	do	12.83					39.7
14. White-heart beech	do	14.92	70		18.80	.24	43.0
15. Yellow birch	do	15.20	70	Immediately	10.39	.30	44.3
16. Red birch	do	15.46	70	25 to 35	8.36	.27	39.2
17. Black willow	do	16.24	70		4.87	(3)	29.0
18. Large tooth aspen	do	16.28	70	45	6.23	.25	27.8
19. White elm	do	16.29	70		8.84	.43	34.2
20. Green ash	do	17.27	70	Immediately	10.61	.45	38.3
21. Slippery elm [2]	do	17.85					27.3
22. Silver maple	do	17.97	70		3.52	.30	36.0
23. Sweet birch	do	18.20	70	(4)	3.85	.30	46.9
24. Red gum	Sapwood	18.33	70		12.96	.33	36.7
25. White ash	Heartwood	18.83	70	4 to 7	8.16	.46	34.3
26. Silver maple	Sapwood	19.78	70	30 to 60	11.17	(3)	32.8
27. Basswood	Heartwood	20.36	70	7 to 12	12.11	.30	31.0
28. Tupelo gum	do	20.90	70	20	9.91	(3)	34.8
29. Wild red cherry	do	25.09	70		10.72	(3)	23.7
30. Tupelo gum	Sapwood	25.21	45	22 to 25	12.33	(3)	33.5

[1] The absorption tests were made in the treating cylinder and in most cases better penetrations were obtained in the species which took the higher absorptions. The pressures and times used in these tests are not comparable to commercial conditions.

[2] Not treated in the penetrance apparatus on account of the open condition of the pores. A good penetration was secured in tests made in the treating cylinder.

[3] Complete. Since the radial penetration of tupelo gum, wild red cherry, black willow, and silver maple was complete the relative order of those species is not important.

[4] Specimens were not straight grained, and oil passed out at the side.

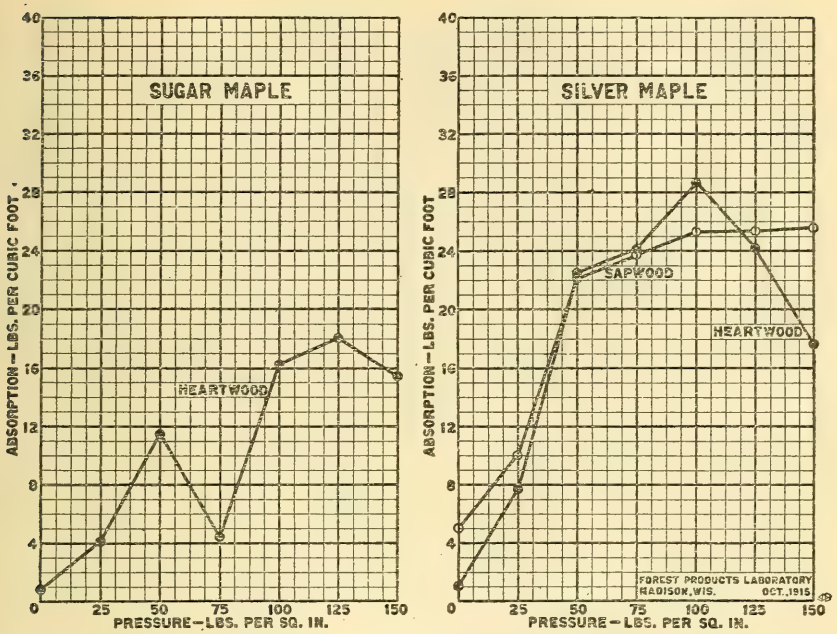


FIG. 14.—Absorption in the heartwood of sugar maple and silver maple and the sapwood of silver maple.

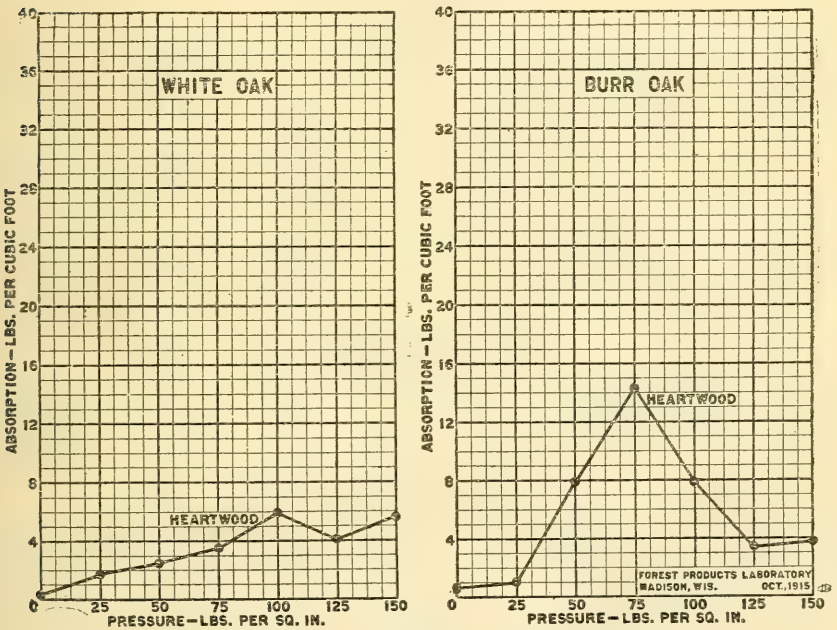


FIG. 15.—Absorption in the heartwood of white oak and bur oak.

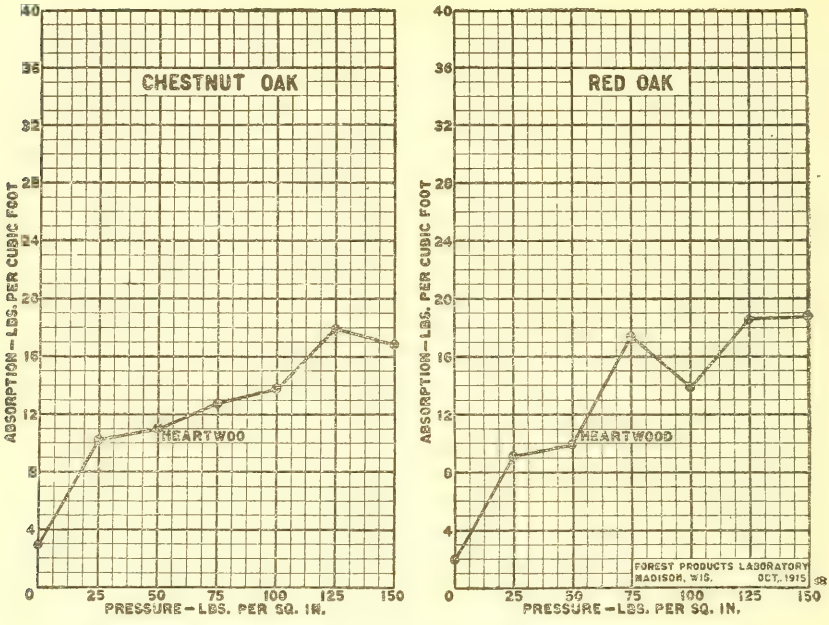


FIG. 16.—Absorption in the heartwood of chestnut oak and red oak.

TABLE 3.—*Results of penetrance tests on individual pieces.*

Piece No.	Moisture.	Average number of rings per inch.	Oven dry weight per cubic feet.	Time of treatment.	Time required to penetrate 24 inches.[1]		Penetrations.				
					First end.	Second end.	Average longitudinal.	Radial.		Tangential.	
								Average.	Maximum.	Average.	Maximum.
	Per ct.		*Pounds.*	*Hours.*	*Min.*	*Min.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
ROCK ELM—HEARTWOOD.											
48	6.1	14	38.40	½	2	3	5.83	0.20	0.30	0.25	0.30
49	2.0	16	37.20	1	½	1	11.65	.40	.50	.30	.60
50		14	39.80	2	2	5	5.50	.40	.50	.40	.60
Average							7.66	.33	.43	.32	.50
RED BIRCH—HEARTWOOD.											
51	12.0	18	39.60	½			8.50	0.30	0.35	0.30	0.40
52	9.7	14	39.30	1	35		8.17	.25	.30	.25	.30
53	6.5	13	38.50	2	25		8.43	.25	.35	.30	.40
Average							8.37	.27	.33	.28	.37
SWEET BIRCH[2]—HEARTWOOD.											
57		20	47.10	½			4.17	0.30	0.35	0.25	0.30
58		21	47.12	1			3.83	.40	.50	.40	.50
59	12.2	18	44.62	2			3.56	.25	.25	.25	.30
Average							3.85	.32	.37	.30	.37

[1] These periods are not comparable to those obtained in commercial treating plants.
[2] Specimens were crooked grain. Oil passed out at side instead of following to end, as it would have done in straight-grained wood.

TABLE 3.—*Results of penetrance tests on individual pieces*—Continued.

Piece No.	Moisture.	Average number of rings per inch.	Oven dry weight per cubic feet.	Time of treatment.	Time required to penetrate 24 inches.		Penetrations.				
					First end.	Second end.	Average longitudinal.	Radial.		Tangential.	
								Average.	Maximum.	Average.	Maximum.
	Per ct.		*Pounds.*	*Hours.*	*Min.*	*Min.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
CHESTNUT—HEARTWOOD.											
60		12	24.00	½			2.96	0.15	0.20	0.20	0.20
61	6.2	13	28.80	1			5.14	.20	.30	.20	.30
62	6.0	13	26.35	2			3.89	.20	.25	.15	.20
Average							4.00	.18	.25	.18	.23
WHITE ASH—HEARTWOOD.											
66	5.0	20	35.50	½	7	7	4.81	0.35	0.50	0.25	0.30
67		16	34.70	1	4		8.84	.50	.60	.50	.60
68	10.6	19	32.85	2			10.83	.52	.60	.45	.50
Average							8.16	.46	.57	.40	.47
HICKORY—HEARTWOOD.											
69	2.9	4	51.60	½			4.50	0.25	0.30	0.30	0.40
70		5	52.50	1			4.83	.30	.40	.25	.30
71		4	52.20	2			8.84	.60	.75	.60	.70
Average							6.06	.38	.48	.38	.47
YELLOW BIRCH—HEARTWOOD.											
30	2.4	12	46.00	½	Immediately.		8.17	0.30	0.30	0.35	0.40
31		14	44.50	1	Do.		10.83	.30	.35	.30	.40
32	7.0	16	42.30	2	Do.		12.16	.25	.30	.30	.45
Average							10.39	.28	.32	.32	.42
SILVER MAPLE—HEARTWOOD.											
33		12	36.24	½			3.50	0.20	0.30	0.30	0.40
34		13	35.70	1			3.56	.30	.40	.40	.60
35		11	36.20	2			3.50	.40	.50	.40	.60
Average							3.52	.30	.40	.37	.53
SILVER MAPLE—SAPWOOD.											
36	4.4	10	32.40	½			7.17	Complete			
37		10	33.17	1	30		14.84	do.[1]			
38		7		2	60		11.50	do.			
Average							11.17				
BASSWOOD—HEARTWOOD.											
39		22	30.30	½			7.00	0.30	0.45	0.30	0.50
40	12.3	20	29.60	1	12	12	14.84	.20	.20	.25	.30
41		18	31.90	2	7	7	14.50	.45	.50	.40	.40
Average							12.11	.32	.38	.32	.40

[1] Complete radial penetration was at least three-fourths inch. Where part of specimens showed complete radial penetration they were not included in the average.

TABLE 3.—*Results of penetrance tests on individual pieces*—Continued.

SYCAMORE—HEARTWOOD.

Piece No.	Moisture.	Average number of rings per inch.	Oven dry weight per cubic feet.	Time of treatment.	Time required to penetrate 24 inches.		Penetrations.				
					First end.	Second end.	Average longitudinal.	Radial.		Tangential.	
								Average.	Maximum.	Average.	Maximum.
	Per ct.		*Pounds.*	*Hours.*	*Min.*	*Min.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
42	5.2	32	35.60	½	.....	.....	3.83	0.20	0.30	0.20	0.30
43	0.1	32	34.40	1	.....	.....	2.94	.30	.40	.30	.30
44	1.0	30	35.50	2	.....	.....	5.75	.20	.30	.20	.30
Average	.....	.....	.....	.....	.....	.....	4.17	.23	.33	.23	.30

LARGETOOTH ASPEN—HEARTWOOD.

45	.....	.....	27.63	½	.....	.....	5.21	0.30	0.40	0.50	0.70
46	2.4	.....	27.15	1	45	.....	11.83	Complete[1]	.....	.....	.....
47	2.2	.....	28.40	2	.....	.....	1.64	.20	.30	.25	.40
Average	.....	.....	.....	.....	.....	.....	6.23	.25	.35	.38	.55

WHITE ELM—HEARTWOOD.

1	1.8	16	29.58	½	.....	.....	8.17	0.50	0.70	0.60	0.70
2	10.5	13	30.61	1	.....	.....	4.17	.40	.50	.50	.60
3	4.8	12	30.71	2	.....	.....	14.18	.40	.60	.60	.60
Average	.....	.....	.....	.....	.....	.....	8.84	.43	.60	.57	.63

GREEN ASH—HEARTWOOD.

9	11.2	12	39.30	½	Immediately..		8.84	0.40	0.45	0.40	0.50
10	11.0	14	36.50	1	.....do.....		9.50	.50	.60	.50	.60
11	.9	13	40.10	2	.....do.....		13.50	Complete[1]	.....	.....	.....
Average	.....	.....	.....	.....	.....		10.61	.45	.52	.45	55

HACKBERRY—HEARTWOOD.

12	.....	8	36.70	½	.....	.....	6.16	0.30	0.40	0.40	0.50
13	.....	10	36.30	1	.....	.....	14.84	.40	.50	.40	.50
14	.....	10	41.70	2	.....	.....	11.50	.30	.40	.30	.40
Average	.....	.....	.....	.....	.....	.....	10.83	.33	.43	.37	.47

HACKBERRY—SAPWOOD.

15	1.5	8	35.20	½	.....	.....	6.16	0.50	0.70	0.60	0.70
17	6.0	10	36.40	2	1	.....	10.16	.40	.50	.40	.50
Average	.....	.....	.....	.....	.....	.....	8.16	.45	.60	.50	.60

BUR OAK—HEARTWOOD.

18	8.3	15	40.70	½	.....	.....	0.83	0.05	0.05	.....	.....
19	8.1	15	41.56	1	.....	.....	.50	.05	.05	.....	.....
20	12.3	16	41.10	2	.....	.....	.50	.05	.05	.....	.....
Average	.....	.....	.....	.....	.....	.....	.61	.05	.05	.....	.....

[1] Complete radial penetration was at least three-fourths inch. Where parts of specimens showed complete radial penetration they were not included in the average.

TABLE 3.—*Results of penetrance tests on individual pieces*—Continued.

TUPELO GUM—HEARTWOOD.

Piece No.	Moisture.	Average number of rings per inch.	Oven dry weight per cubic feet.	Time of treatment.	Time required to penetrate 24 inches.		Penetrations.				
					First end.	Second end.	Average longitudinal.	Radial.		Tangential.	
								Average.	Maximum.	Average.	Maximum.
	Per ct.		*Pounds.*	*Hours.*	*Min.*	*Min.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
24		11	36.45	½			10.83	Complete [1]			
25	19.5	10	32.20	1			8.08				
26		12	35.07	2	20		10.83				
Average							9.91				

TUPELO GUM—SAPWOOD.

27	3.0	15	31.40	½	20	22	8.17	Complete [1]			
28	0.5	14	32.53	1	22	20	16.50	do			
Average							12.33				

BLACK WILLOW—HEARTWOOD.

71	0.6	4	29.05	½			4.83	0.25	0.30	0.30	0.40
72	1.8	4	29.09	1			6.28	Complete [1]			
73		4	28.62	2			3.50	do			
Average							4.87				

SUGAR MAPLE—HEARTWOOD.

74	3.2	22	43.75	½			3.83	0.15	0.20	0.20	0.30
75	8.5	18	43.15	1			6.84	.25	.30	.20	.32
Average							5.33	.20	.25	.20	.31

WHITE OAK—HEARTWOOD.

77		16		½			1.50	0.07	0.1		
78		17		1			2.62	.07	0.1		
79		16		2			2.83	.10	0.1		
Average							2.32	.08	0.1		

RED GUM—HEARTWOOD.

80	8.0		40.12	½			1.28	0.07	0.10	0.10	0.20
81			38.63	1			1.50	.15	.02	.08	.15
82	15.2		38.32	2			1.28	.05	.05	.10	.10
Average							1.35	.09	.12	.09	.15

RED GUM—SAPWOOD.

54		14	38.58	½	3	8	16.16	0.35	0.40	0.40	0.50
55	1.8	14	35.70	1	1	3	10.21	Complete [1]			
56		16	35.70	2	2	10	12.50	.30	.50	.40	.60
Average							12.96	.32	.45	.40	.55

[1] Complete radial penetration was at least three-fourths inch. Where part of specimens showed complete radial penetration they were not included in the average.

TABLE 3.—*Results of penetrance tests on individual pieces*—Continued.

WHITE HEART BEECH.

Piece No.	Moisture.	Average number of rings per inch.	Oven dry weight per cubic feet.	Time of treatment.	Time required to penetrate 24 inches.		Penetrations.				
					First end.	Second end.	Average longitudinal.	Radial.		Tangential.	
								Average.	Maximum.	Average.	Maximum.
	Per ct.		*Pounds.*	*Hours.*	*Min.*	*Min.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
86	6.7	8	43.20	½	.....	.....	14.8	0.18	0.25	0.20	0.30
87	7.6	7	42.80	1	.....	.....	18.1	.30	.40	.30	.40
88	.....	8	.....	2	.....	.....	23.5	Complete [1]		.....	.....
Average	.....	.....	.....	.....	.....	.....	18.8	.24	.32	.25	.35

RED HEART BEECH.

89	9.0	17	41.00	½	.....	.....	0.50	0.05	0.05	.....	.....
90	8.9	16	40.60	1	.....	.....	.43	.05	.05	.....	.....
91	.....	15	.....	2	.....	.....	.57	.05	.05	.....	.....
Average	.....	.....	.....	.....	.....	.....	.50	.05	.05	.....	.....

WILD RED CHERRY—HEARTWOOD.

83	.....	6	23.82	½	.....	.....	8.17	Complete [1]		.....	.....
84	3.5	5	23.50	1	.....	.....	12.50	.....do		.....	.....
85	.....	6	.....	2	.....	.....	11.50	.....do		.....	.....
Average	.....	.....	.....	.....	.....	.....	10.72	.....	.....	.....	.....

[1] Complete radial penetration was at least three-fourths inch. Where part of specimens showed complete radial penetration they were not included in the average.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 607

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER June 7, 1918

TESTS OF THE ABSORPTION AND PENETRATION OF COAL TAR AND CREOSOTE IN LONGLEAF PINE.

By CLYDE H. TEESDALE, *in charge, Section of Wood Preservation*, and J. D. MACLEAN, *Assistant Engineer in Forest Products.*

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INTRODUCTION.

One of the most important questions in the preservative treatment of wood is the cost of the preservative. Particularly is this true when creosote is used, and anything which will tend to reduce the cost of this preservative without decreasing its efficiency will be a direct aid to the industry. The use of tar and creosote mixtures in the preservative treatment of wood has increased rapidly in recent years, particularly in the treatment of wood paving blocks. This is due largely to the fact that the tar and creosote mixtures can be produced more cheaply than can creosote containing no tar. There are two other factors, however, aside from cost which must be considered as affecting the use of tar and creosote mixtures. A preservative treatment, to be effective, should show good absorption and penetration and the preservative must be toxic to wood-destroying fungi.[1]

This paper reports the results of an investigation into the effect of tar in creosote upon absorption and penetration of the preservative. The study was made at the Forest Products Laboratory, maintained by the Forest Service, United States Department of Agriculture, in cooperation with the University of Wisconsin at Madison, Wis.[2]

[1] In general the toxicity of tar and creosote mixtures is sufficient to warrant their use in preservatives. Toxicity of wood preservatives is discussed in Bulletins 155 and 227 of the Department of Agriculture.

[2] Acknowledgments are made to Mr. F. M. Bond, formerly of the Forest Service, under whose direction a portion of this work was done.

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The most important variables in the treatment of wood affecting absorption and penetration are: (1) The species, character, and condition of the wood; (2) the properties of the oil; and (3) the methods of treatment. To eliminate the variability due to species, and reduce that due to the character and condition of the wood, the experiments were confined to wood of one species (longleaf pine), and so far as possible specimens of uniform quality were selected. This made more readily determinable the relative importance of variations in the oil and in methods of treatment.

The relative absorptions and penetrations were determined by two forms of tests:

1. Penetrance tests, in which the preservative was applied to a small area in the specimen and measurements made of the penetrations secured.[1]

2. Impregnation tests, in which the specimens were treated with the preservative under pressure in a cylinder.

The bulletin describes (a) tests made with mixtures of coal-tar creosote and coal tar from which the free carbon had been removed and similar mixtures containing varying amounts of free carbon; and (b) tests made with commercial coal-tar creosotes. The object in both cases was to determine the effect on penetration of differences in the preservative.

The bulletin also gives the results obtained in experiments to determine the effect of varying pressure, time of treatment, and temperature. The object of these experiments was to determine whether, by increasing the time of treatment, intensity of pressure, and temperature of preservative, absorptions and penetrations could be obtained with tar and creosote mixtures equivalent to those obtained with creosote, and to determine which of these factors was the most important.

MATERIALS USED.

WOOD.

Selected air-dried heartwood of longleaf pine was employed in all of the experiments. The specimens used in the penetrance tests were approximately 2 inches by 4 inches in cross section and of varying lengths from 18 inches to 24 inches. Pieces cut from the same stick were regarded as matched and were designated as a set of specimens. Test pieces selected in this manner were more uniform in structure than unmatched material, and the variables introduced by differences in structure were thus reduced. From two to four sets of matched specimens were used in each series of tests, the results being averaged for each test. Where these results are represented graphically, each figure includes only tests with such matched speci-

[1] A description of the apparatus used (fig. 14) is given in the Appendix.

mens, and comparisons can not be made by combining data used in separate figures.

The number of specimens used in each test is shown in the tables in the appendix. Specimens for the cylinder treatments discussed on pages 6 and 9 were paving blocks 4 inches long cut from two sticks of air-dry commercial paving block stock approximately 4 inches by 8 inches in cross section. In each of the tests a treatment was made on one block from each stick, thus giving two blocks treated with the same preservative. Blocks used in the tests on the effect of varying time, pressure, and temperature were all cut from the same stick, the material being similar to that used in the impregnation tests. Four blocks were treated with each preservative. In all of the impregnation tests, the results for each treatment were averaged.

Comparisons of individual tests from different sets of specimens should not be made, because such comparisons would not represent matched specimens. Specimens in the different sets may have been obtained from different trees.

PRESERVATIVES.[1]

Six commercial coal-tar creosotes from different sources and of varying specific gravities and five coal tars from by-product ovens and gas-house plants were used in the experiments. The general characteristics of these preservatives were as follows:

Characteristics of preservatives used.

Coal-tar creosotes.			Coal tars.		
No.	Kind.	Specific gravity at 60°C.	No.	Kind.	Free carbon.
					Per cent.
1	Coal-tar creosote containing coal tar (estimated at about 10 per cent).	1.0483	1	By-product coke-oven tar	6.0
2	Coal-tar creosote	1.0475	2	By-product coke-oven tar	16.0
3	Coal-tar creosote	1.0576	3	Gas-house coal tar	30.0
4	Coal-tar creocote containing coal tar (estimated at less than 5 per cent).	1.0710	4	By-product coke oven-refined tar.	7.0
5	High boiling coal-tar creosote	1.1050	5	By-product coke-oven tar	14.0
6	Coal-tar creosote	1.0470			

PREPARATION OF MIXTURES FOR THE TESTS ON THE EFFECT OF DIFFERENCES IN THE PRESERVATIVE.

The free carbon was extracted[2] from tars Nos. 1, 2, and 3. Each of these tars was then mixed with creosote No. 4 in the following proportions (by volume at 160° F.):

[1] Analyses of the creosotes are given in the Appendix. Distillation analyses of the tars were not made.

[2] See appendix for method of extraction.

Per cent of total mixture by volume.

Creosote No. 4.	Tar.
100	0
75	25
50	50
25	75
0	100

In order to obtain data on the effect of free carbon on absorption and penetration, it was necessary to vary the amount of free carbon in each of the three tars. This was accomplished by combining the proper proportions of normal [1] tar with tar of the same origin from which the free carbon had been removed. These mixtures were made by weight. The tars containing the varying percentages of free carbon were then mixed with creosote by volume in the proportion of 50 per cent tar and 50 per cent creosote.

CHARACTER OF FREE CARBON.

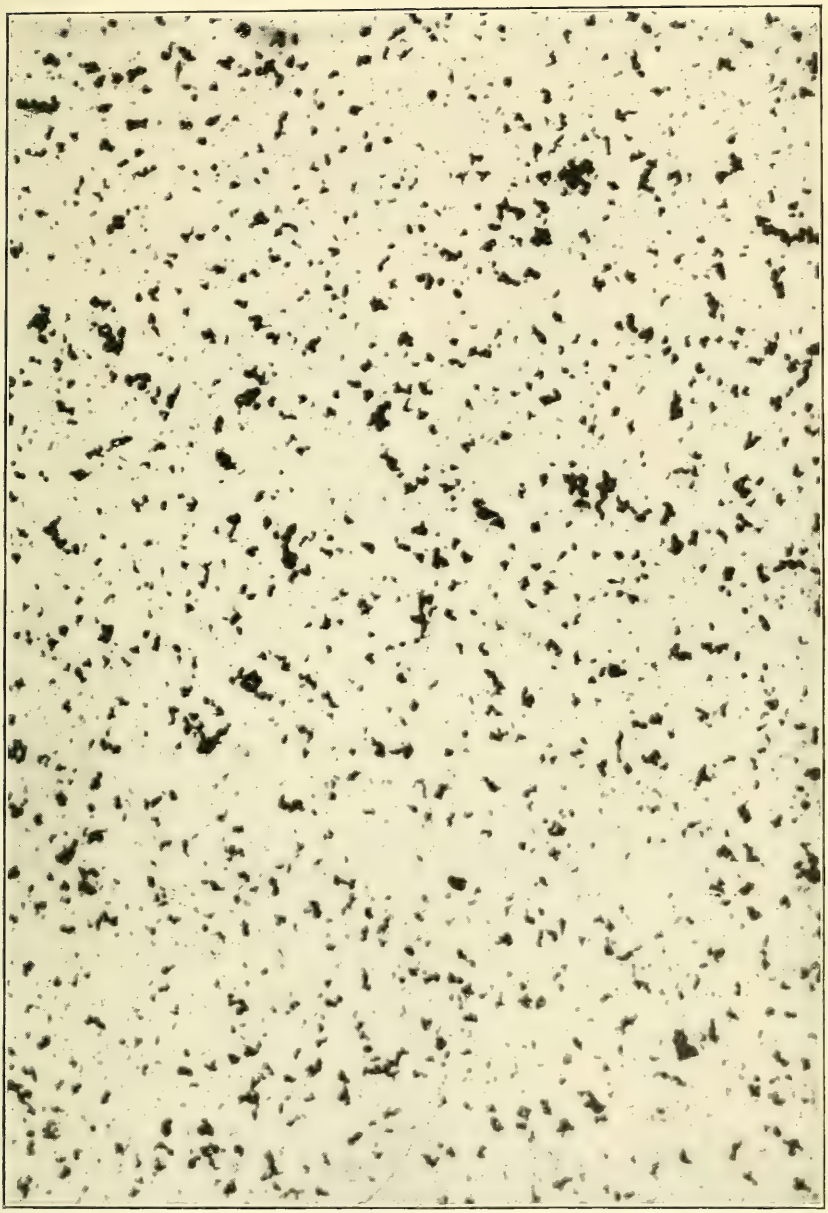
The free carbon was extracted with the least difficulty from the tar containing the highest percentage of free carbon (tar No. 3) and with the most difficulty from the tar containing the lowest percentage of free carbon (tar No. 1). A greater number of filtrations were required with tar No. 1, and a mat of free carbon of given thickness was more inclined to be impervious to additional tar than in the case of the other tars. The carbon mat formed from the tar having the largest amount of free carbon appeared to be the most pervious.

Tars Nos. 1, 2, and 3 were examined under the microscope at a magnification of 400 diameters. Plates I to III, inclusive, are photomicrographs of thin films of mixtures of equal parts by volume of creosote and each of the three normal tars. It is evident that the free carbon agglomerations are largest in the tar containing the highest percentage of free carbon.

PRESERVATIVES USED FOR THE TESTS ON THE EFFECT OF VARYING TIME, PRESSURE, AND TEMPERATURE.

By-product coke-oven tars Nos. 1, 4, and 5, and coal-tar creosotes Nos. 4 and 6 were used in the experiments described on page 12. The proportion of tar and creosote in the mixtures and the temperatures, pressures, durations of treatment, and the results obtained are given in figures 18 to 27 and in tables 15 to 21 in the Appendix.

[1] By normal tar is meant tar containing its original free carbon.

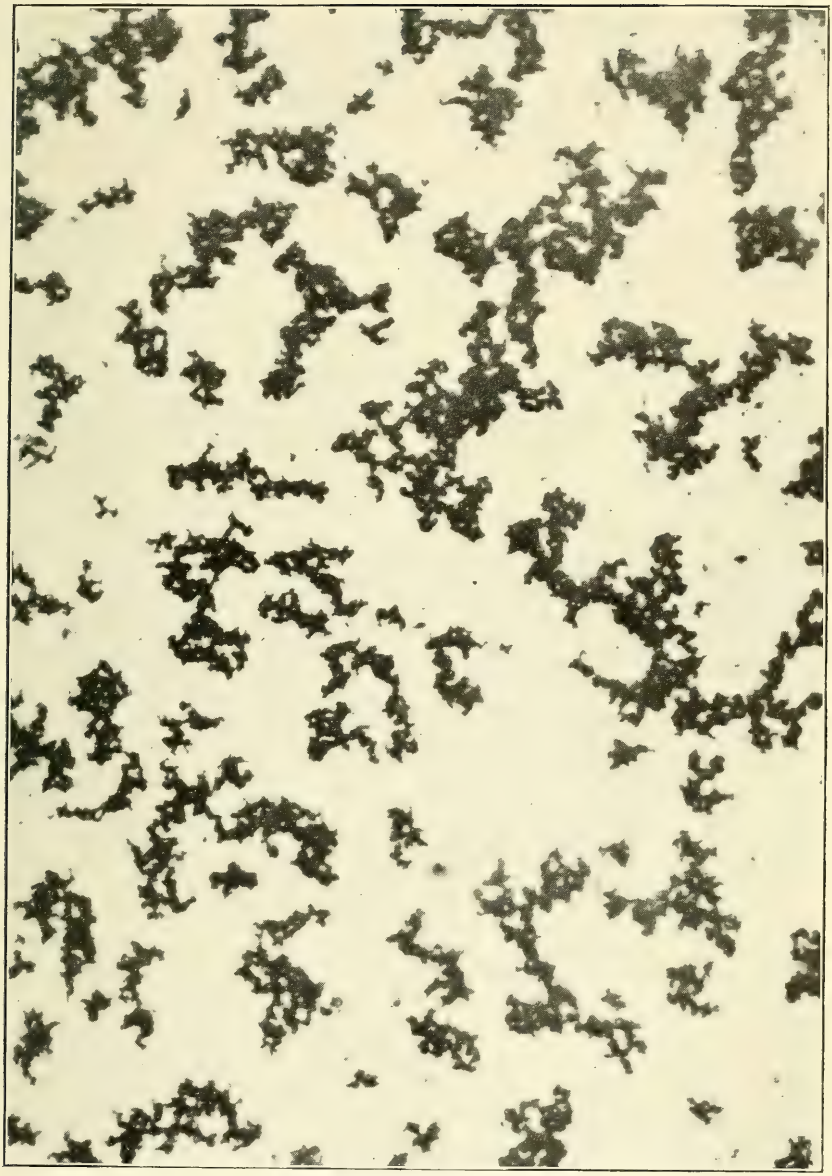


A THIN FILM OF A MIXTURE OF EQUAL PARTS, BY VOLUME, OF CREOSOTE AND NORMAL BY-PRODUCT COKE-OVEN TAR NO. 1 (NORMAL AMOUNT OF FREE CARBON IN TAR, 6 PER CENT, BY WEIGHT).

Magnification, about 400 diameters.

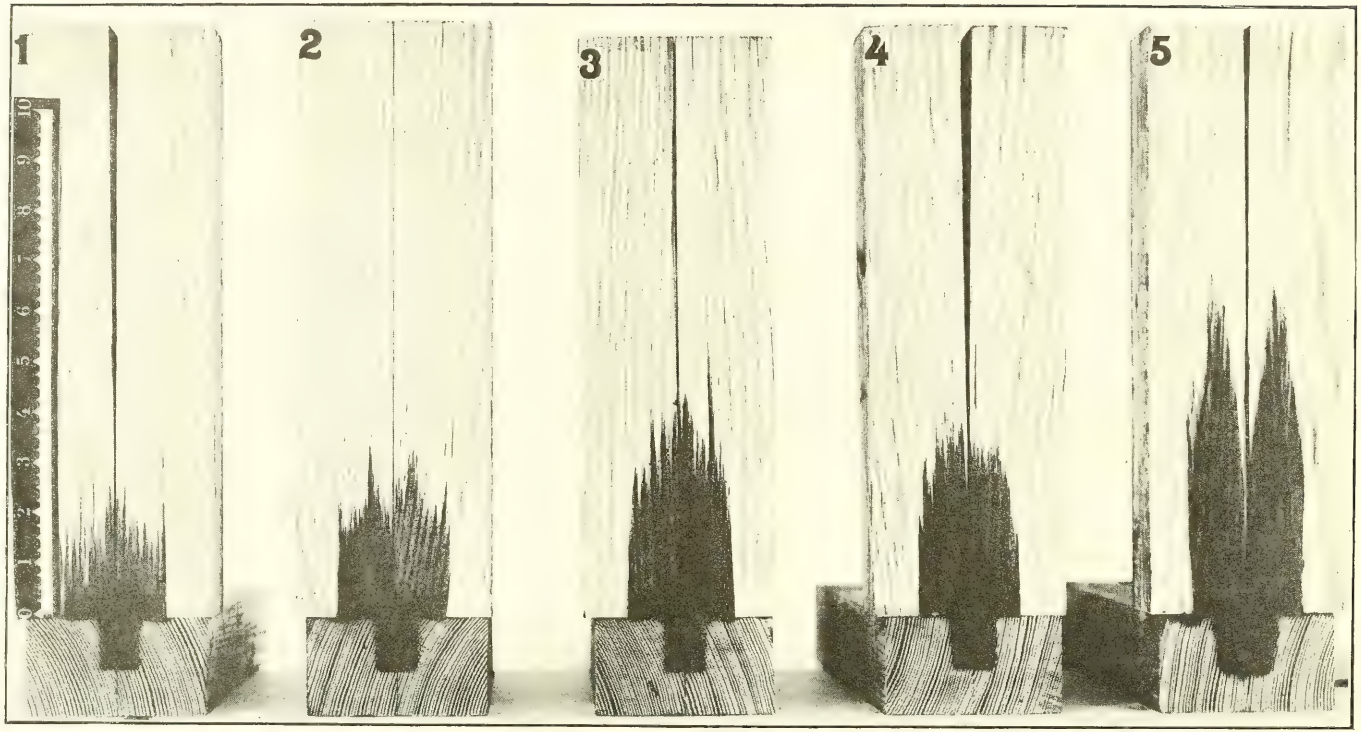
A THIN FILM OF A MIXTURE OF EQUAL PARTS, BY VOLUME, OF CREOSOTE AND NORMAL BY-PRODUCT COKE-OVEN TAR NO. 2 (NORMAL AMOUNT OF FREE CARBON IN TAR, 16 PER CENT, BY WEIGHT).

Magnification, about 400 diameters.



A THIN FILM OF A MIXTURE OF EQUAL PARTS, BY VOLUME, OF CREOSOTE AND A NORMAL GAS-HOUSE TAR NO. 3 (NORMAL AMOUNT OF FREE CARBON IN TAR, 30 PER CENT, BY WEIGHT).

Magnification, about 400 diameters.



MATCHED SPECIMENS OF LONGLEAF PINE TREATED WITH MIXTURES OF CREOSOTE NO. 4 AND A CARBON-FREE GAS-HOUSE TAR NO. 3 (NORMAL AMOUNT OF FREE CARBON IN TAR, 30 PER CENT, BY WEIGHT). (DATA IN TABLE 3, P. 29, AND TABLE A, P. 42.)

Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature, 160° F.

EFFECT ON PENETRATION OF DIFFERENCES IN THE PRESERVATIVE, ESPECIALLY THE EFFECT OF FREE CARBON.

Experiments with various mixtures of creosote and tars from which the free carbon had been removed were first made in the penetrance apparatus, the temperature, pressure, and time of treatment being kept constant. These tests were followed by cylinder treatments on paving blocks, with the same mixtures but with the time of treatment and the pressure varied to obtain an absorption of 16 pounds of preservative per cubic foot of wood. A similar series of penetrance and impregnation tests were made, using tar and creosote mixtures containing varying amounts of free carbon. Further tests were then made in the penetrance apparatus with five commercial coal-tar preservatives.

In the series of tests to determine the effect of differences in the preservative on penetration, the operative features were always the same A pressure of 75 pounds per square inch and a treating period of two hours were used. The temperature of the preservative and of the penetrance oven, in which the specimens were treated, was 160° F.

The treatments were made on two sets of specimens, each set containing from four to six matched specimens. Thus, each point on the curves of figure 4 represents the average of the results obtained on two specimens. The sets of specimens were not, however, matched with each other. For example (see Table 1, appendix), specimens 19a and 35 were not matched, but specimens 19a, 28, 32, 29, and 30, and specimen 35, 23a, 22a, 24a, and 20a were matched with each other.

MIXTURES OF CARBON-FREE TAR AND CREOSOTE.

Penetrance tests.[1]—(Tables 1 to 4, inclusive, and figs. 1 and 2.)

In these experiments, made with mixtures of tars Nos. 1, 2, and 3 with creosote No. 4, it is evident that as the proportion of the carbon-free tar in the mixture was increased the specific gravity and viscosity of the mixture increased and the absorptions and penetrations decreased. Each point on the absorption and penetration curves of figure 1 represents the results obtained with one tar and creosote mixture.

A comparison of these tars and their relative effect upon absorption and penetration is given in Table 4 and figure 2. These treatments were made with mixtures of equal parts by volume of creosote and each of the three carbon-free tars. Each point on the curves of figure 2 represents the average of the results obtained on two specimens, as in figure 1.

Figure 2 also shows the results obtained with similar mixtures of the same tar, except that the free carbon was not removed, and hence

[1] The data are given in Tables 1 to 4 of the Appendix.

gives a direct comparison for studying the effect of the free carbon on absorption and penetration.

The results of the tests indicate that smaller penetrations and absorptions were obtained with the mixtures of those tars which had contained the larger amounts of free carbon, whether the free carbon was present or had been removed. Variations in absorption and penetration of the different tar mixtures, therefore, appeared to be

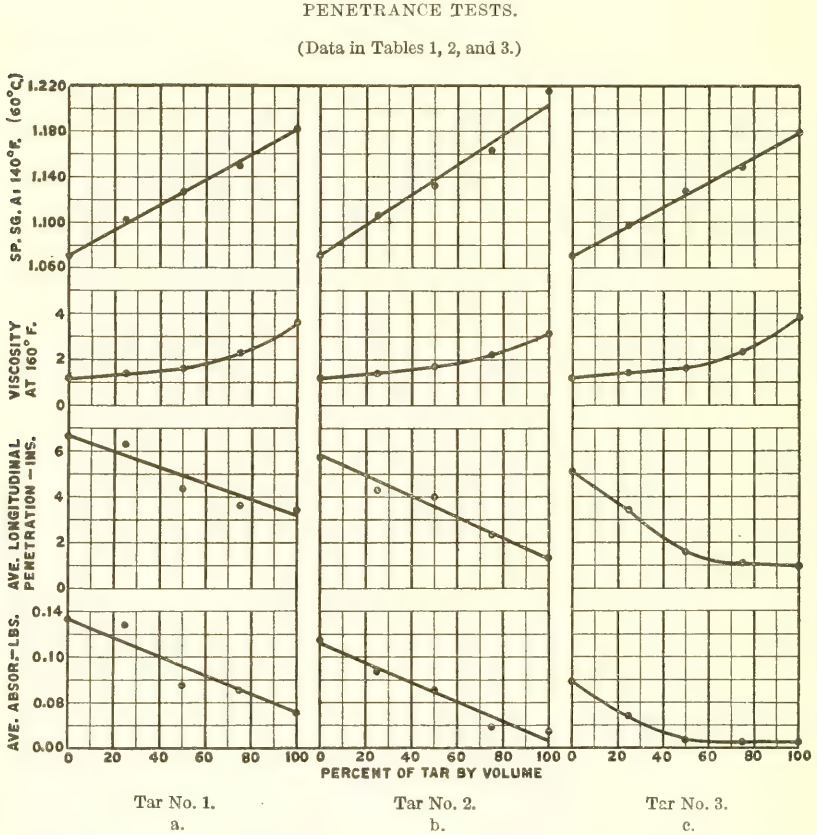


FIG. 1.—The relative absorptions and penetrations into longleaf pine of mixtures of creosote No. 4 and carbon-free tars Nos. 1, 2, and 3. Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature of preservative, 160° F.

caused by a difference in the composition of the bitumens in the three tars, as well as by the amount and character of the free carbon present.

Impregnation tests.—(Tables 5 to 7 and fig. 3.)

The paving block specimens were treated in a small cast-iron cylinder, inclosed in the penetrance oven, and with air pressure and vacuum connections. Two blocks were employed for each test, and the results averaged for each piont on the curves shown in figure 3.

Inasmuch as there were two variables in these tests, namely, time of treatment and the pressure, it was necessary to consider both of these factors; hence, the product of pressure and time has been used in the data presented. The tests were made at a higher temperature and pressure than were the penetrance tests but the mixtures were the same. In making the tests the temperature was kept constant.

The addition of tar made necessary the use of increased pressure or time of treatment or both to obtain the same absorption of preservative as was obtained with creosote.

After the tests, the blocks were split to determine the penetration and in most cases they were found to be fairly well penetrated when given an absorption of 16 pounds per cubic foot. However, a tendency to variation in penetration was greater in the blocks treated with the heavier and more viscous tar mixtures. Unpenetrated areas were found near the centers of some of the blocks which had been treated with preservatives containing 75 per cent and 100 per cent of tar.

MIXTURES OF CREOSOTE AND TAR WITH VARYING AMOUNTS OF FREE CARBON.

Penetrance tests.—(Tables 4, 8, 9, and 10 and figs. 2 and 4.)

The curves shown in figure 4 indicate that the influence of free carbon on penetration and absorption was greatest in the mixture made from tar No. 1, which contained normally 6 per cent of free carbon.

The curves also indicate that with an increase in the percentage

PENETRANCE TESTS.

(Data in Table 4.)

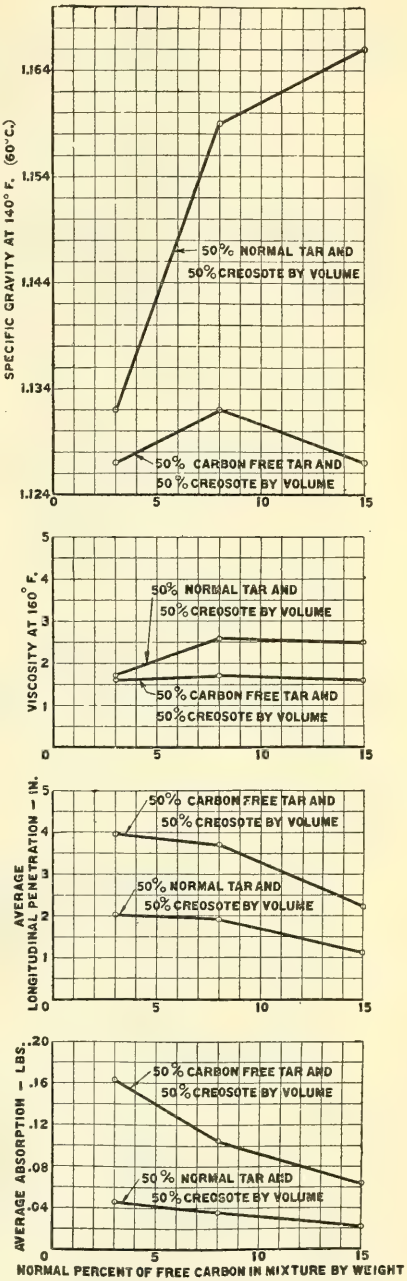


FIG. 2.—The relative absorptions and penetrations into longleaf pine of mixtures of equal proportions of creosote (No. 4) and three different tars (Nos. 1, 2, and 3). Two mixtures were made of each tar. The free carbon was removed from the tar in one mixture and the other contained the normal amount of free carbon. Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature of preservative, 160° F.

of free carbon in the mixture there was a decrease in the absorption and penetration. However, in the case of mixtures with tar No. 3 (fig. 4, *c*) after a certain point was reached there was a rise in the penetration and absorption curves upon the addition of larger per-

IMPREGNATION TESTS.

(Data in Tables 5, 6, and 7.)

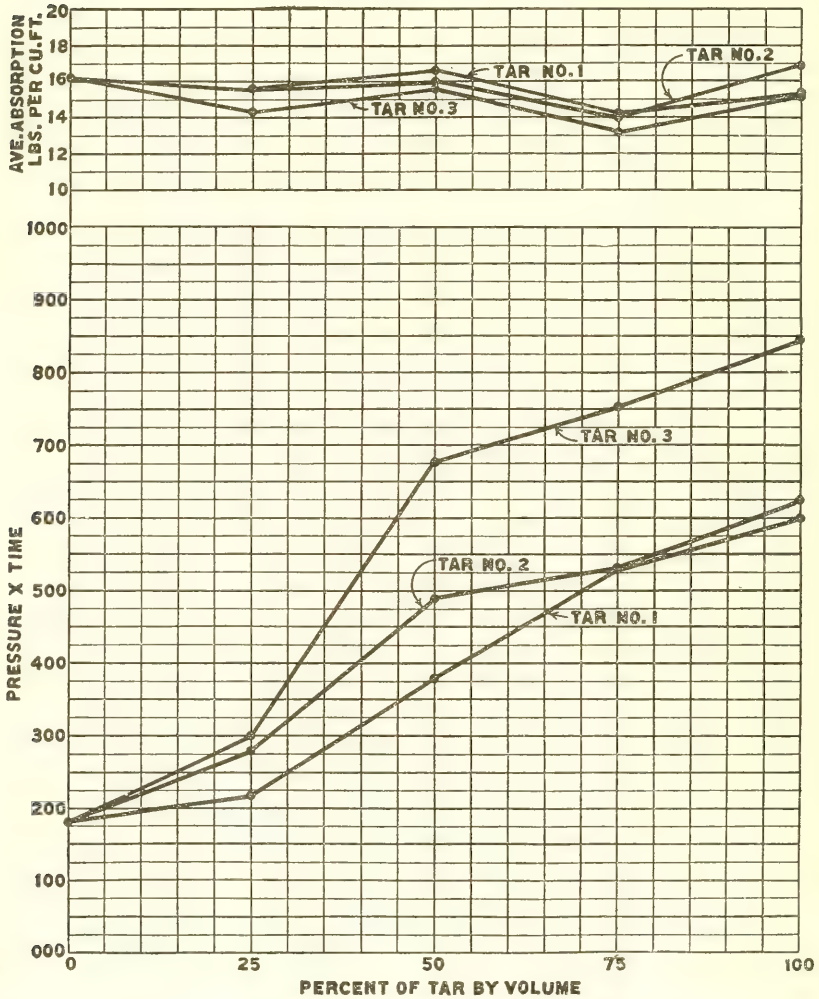
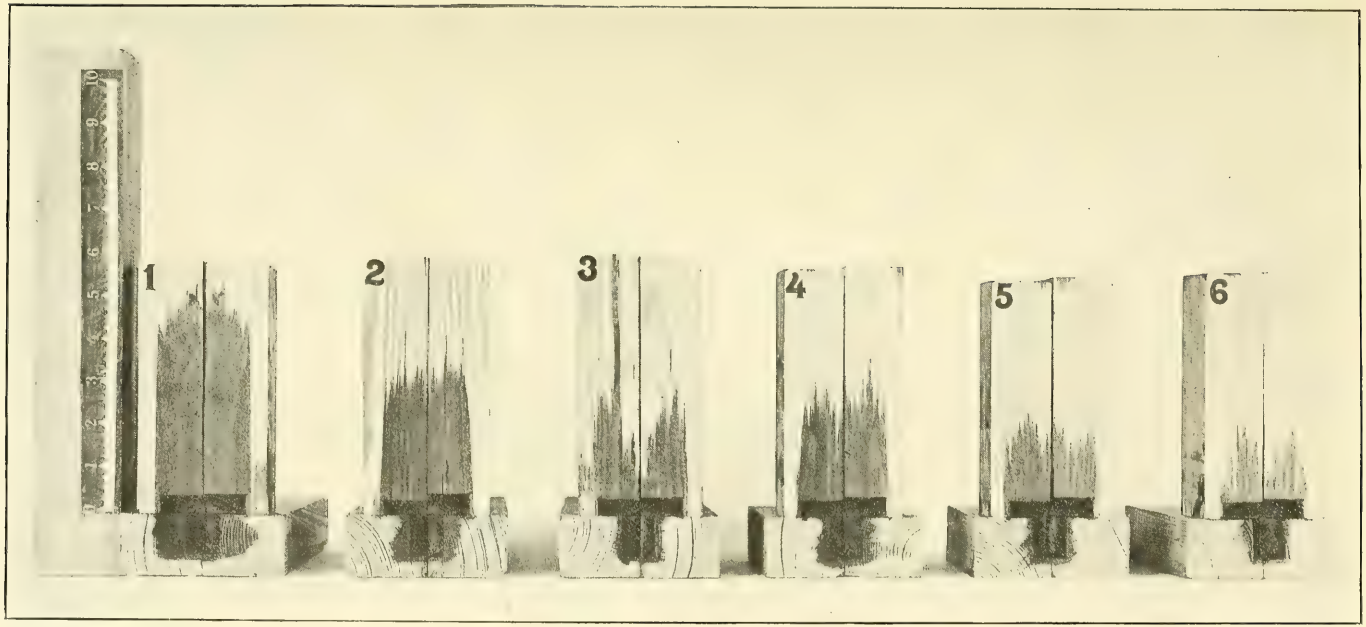


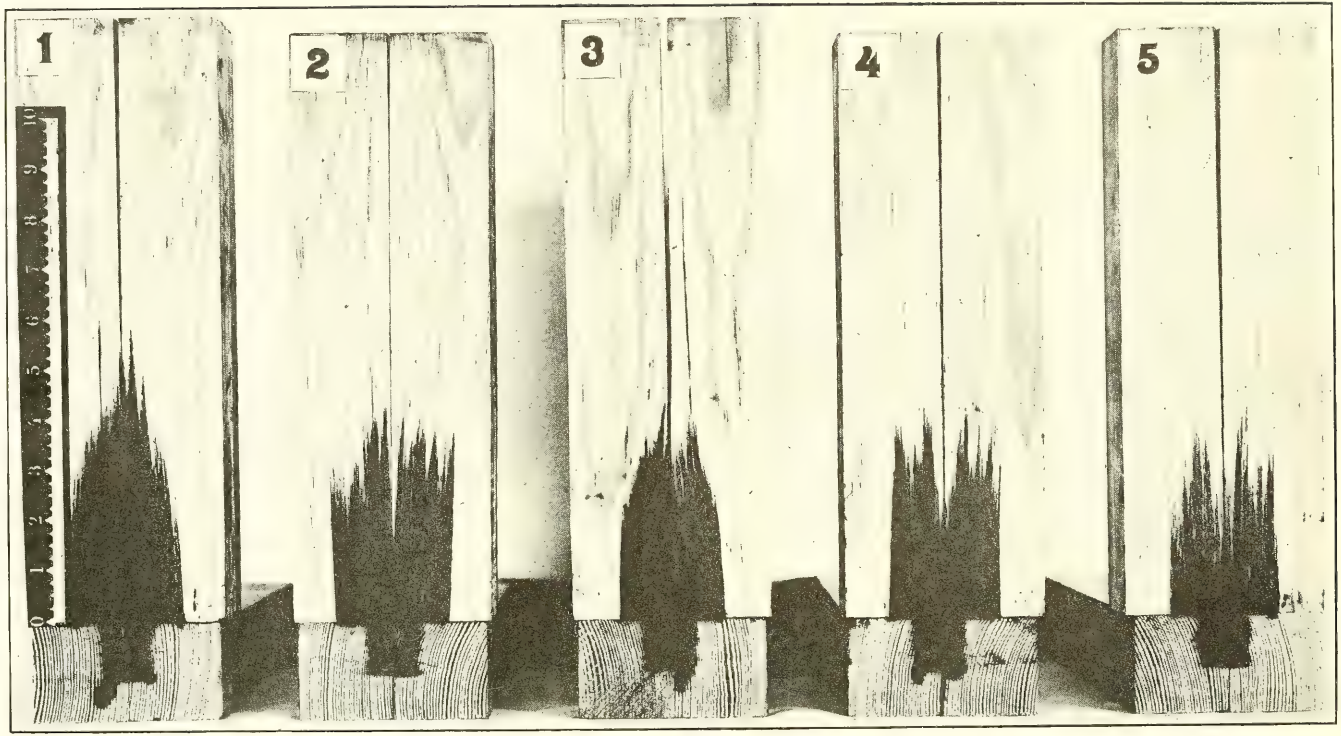
FIG. 3.—The variation in time of treatment and pressure necessary to secure a given absorption in paving blocks using mixtures of creosote No. 4 and carbon-free tars Nos. 1, 2, and 3.

centages of free carbon to the mixture. It is probable that this was caused by the character of the free carbon mats formed on the surface of the wood as the mixture was forced into the interior of the specimens. The free carbon particles in tar No. 3 were very much



MATCHED SPECIMENS OF LONGLEAF PINE TREATED WITH MIXTURES OF EQUAL PROPORTIONS OF CREOSOTE NO. 4 AND THREE DIFFERENT CARBON-FREE AND NORMAL-FREE CARBON TARS, NOS. 1 TO 3. (DATA IN TABLE 4, P. 30, AND TABLE B, P. 42.)

Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature, 160° F.



MATCHED SPECIMENS OF LONGLEAF PINE TREATED WITH MIXTURES OF EQUAL PARTS OF CREOSOTE NO. 4 AND A BY-PRODUCT COKE-OVEN TAR NO. 2 CONTAINING DIFFERENT AMOUNTS OF FREE CARBON (NORMAL AMOUNT OF FREE CARBON IN TAR, 16 PER CENT, BY WEIGHT). (DATA IN TABLE 9, P. 33, AND TABLE C, P. 42.)

Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature, 160° F.

larger than those in tars 1 and 2, and formed a less impervious mat. It seems probable that the mat formed with this tar containing its normal amount of free carbon contained openings as large and as easily penetrated as those formed when part of the carbon was removed.

PENETRANCE TESTS.

(Data in Tables 8, 9, and 10.)

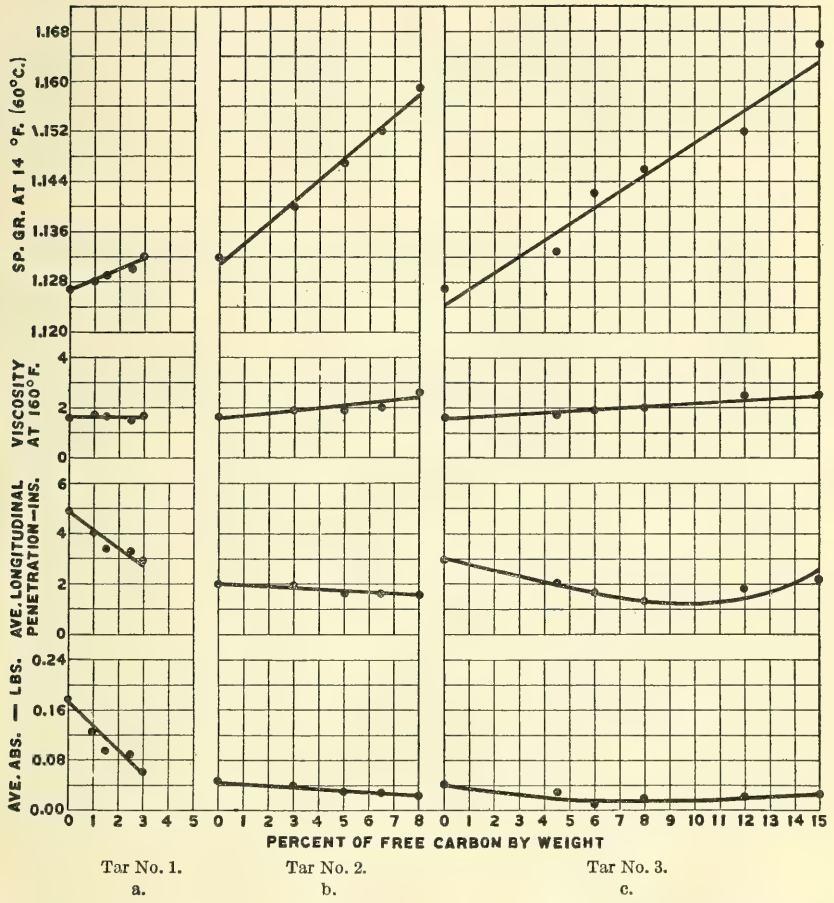


FIG. 4.—The relative absorptions and penetrations into longleaf pine using mixtures of equal parts of creosote No. 4 and tars containing different amounts of free carbon. Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature of preservative, 160° F.

Impregnation tests.—(Tables 11 to 13 and fig. 5).

Impregnation tests were made on paving blocks, using the same mixtures, with varying amounts of free carbon, that were used in the penetrance tests.

As in the impregnation treatments with carbon-free tar and creosote, two blocks were used for each test, and the time of treatment and

pressure were varied so as to obtain approximately 16 pounds absorption per cubic foot.

Figure 5 indicates that when the amount of free carbon in the mixtures was increased, the difficulty of securing a given absorption

IMPREGNATION TESTS.

(Data in Tables 11, 12, and 13.)

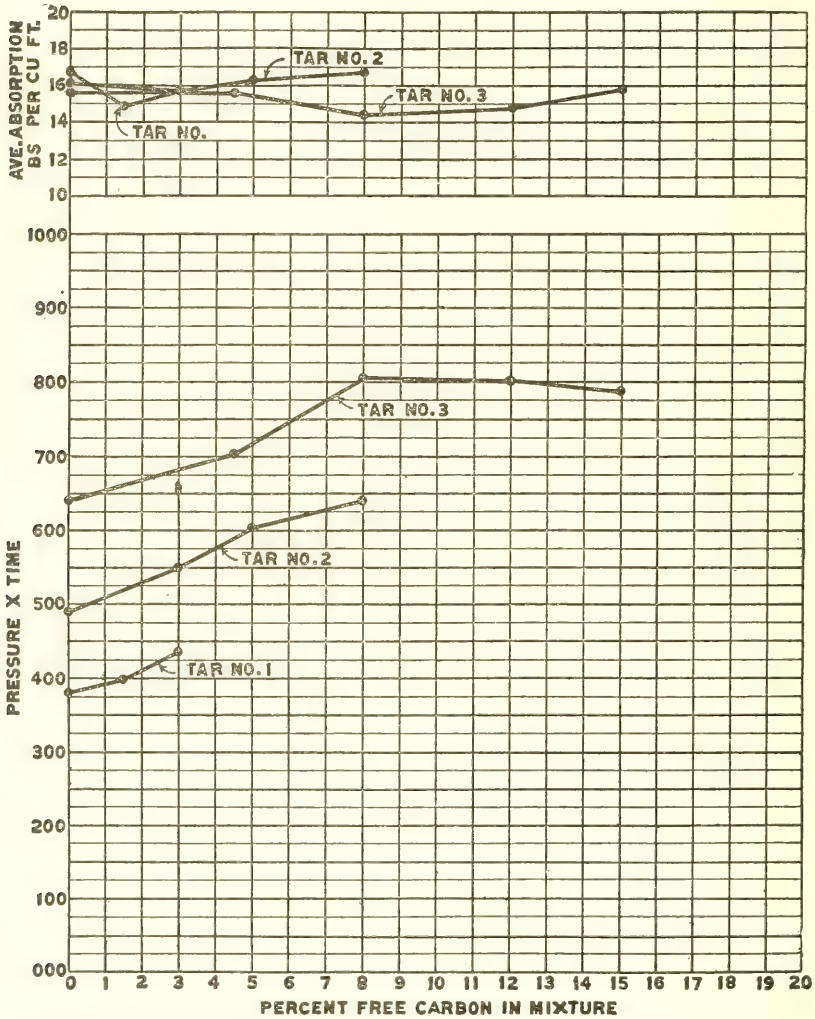


FIG. 5.—Variation in time of treatment and pressure necessary to secure a given absorption in paving blocks using mixtures of equal parts creosote No. 4 and tars having different amounts of free carbon.

was increased. As in the penetrance tests, however, the effect of free carbon was variable in the mixtures containing tar No. 3. The retarding effect of free carbon apparently decreased when the amount in the mixtures was increased beyond a certain point. This was

probably due, as noted in the case of the penetrance tests, to the character of the carbon mat which formed when this tar was used.

Blocks treated with the mixtures containing varying amounts of free carbon were found to be fairly well penetrated. By using a sufficient treating period and pressure, and a temperature of 200° F., it was possible to obtain 16 pounds absorption per cubic foot in all of the treatments on paving blocks.

The experiments taken in conjunction with the penetrance tests, indicate that three factors influenced absorption and penetration, namely, (1) the composition or per cent of bitumens contained in the tar, (2) the amount of free carbon contained in the mixture, and (3) the condition of the carbon or size of the free carbon agglomerations.

INFLUENCE OF COMPOSITION OF THE TARS.

The influence of the composition or per cent of bitumens contained in the tar is shown by the fact that the addition of high-carbon tars to creosote retarded penetration more than similar additions of low-carbon tars, even though the carbon had been removed. The amount of carbon in tar depends to a considerable extent upon the temperature at which it is produced, the higher temperatures producing tars with greater carbon content. It is concluded that tars produced at high temperatures may have a greater effect in retarding penetration than those produced at lower temperatures, whether or not the carbon is removed. Experience has shown that tars having a high carbon content also usually have a high bitumen content.

The condition of the free carbon apparently had a greater influence on absorption and penetration than the amount contained in the mixture. Since the free-carbon agglomerations were largest in the tar containing the highest percentage of free carbon (tar No. 3), this probably accounts for the relatively slight retarding influence of the free carbon in this tar, on absorption and penetration. In the mixtures containing smaller amounts of free carbon, the free carbon particles would come in closer contact with the vessels in the wood, thereby decreasing the absorption and penetration.

PENETRATION OF FREE CARBON INTO WOOD.

In order to determine whether any of the free carbon had penetrated the wood, sections were taken of specimens of heart longleaf pine treated with mixtures of equal parts of creosote and tars Nos. 1, 2, and 3, containing the normal amounts of free carbon. These sections were taken just below the surface through which the preservative entered. A microscopic examination was made at a magnification of 400 diameters but no free carbon could be observed in the wood cells. Some of the preservative was squeezed out of the wood sections in small globules and examined under the microscope. In this case

no free carbon could be detected at the magnification used. The sections were further treated with chloroform and xylol separately to remove the treating oils. Examination with the microscope, of these resulting solutions, also failed to show the presence of free carbon.

Dr. Irving W. Bailey [1] has shown that extremely finely divided carbon particles in certain India inks will penetrate wood, but such carbon particles can not be compared with the much larger ones occurring in coal tars.

TESTS WITH MISCELLANEOUS COMMERCIAL CREOSOTES.

Penetrance tests.—(Table 14 and fig. 6.)

Creosotes Nos. 1 to 5 were used in experiments to determine the penetrations and absorptions of miscellaneous commercial creosotes, the specific gravities varied from 1.0475 to 1.105 at 60° C., thus covering a wide range of oils. The method of treatment was the same for each oil. Creosotes Nos. 1 and 4 contained some tar, while creosotes 2 and 3 were free from tar. Figure 6 shows how the tar tended to retard the penetration. It will also be noted that creosotes Nos. 1 and 5, both oils being free from tar, had similar absorptions and penetrations, although the specific gravity of No. 1 was 1.05 while No. 5 was 1.12. This shows the wide variation that can exist in the specific gravity of oils free from tar, with but little difference in the penetrating properties.

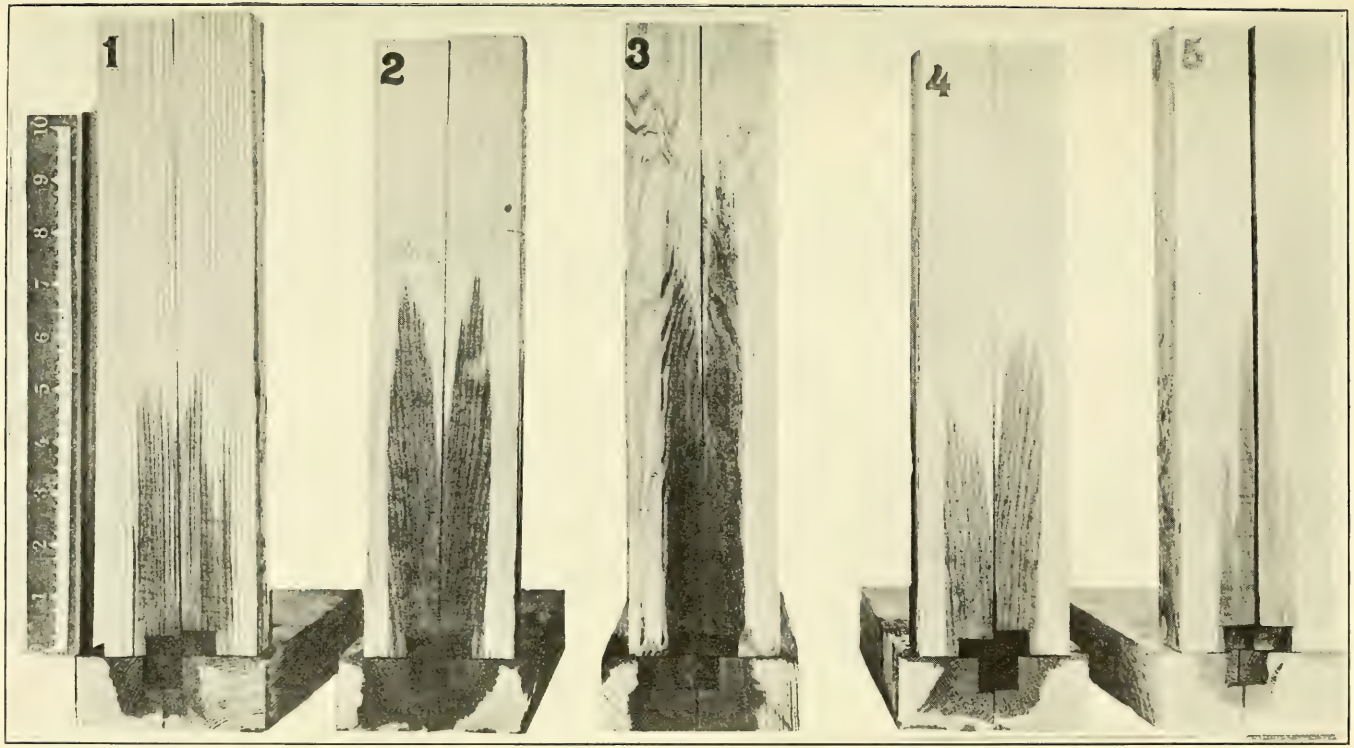
INFLUENCE OF VISCOSITY.

The viscosities of mixtures of a given tar and creosote in general increased (1) as the per cent of tar was increased, (2) as the per cent of free carbon was increased, (3) or as the temperature was lowered and in these mixtures the absorptions and penetrations generally decreased as the viscosity increased. When different tars were used in the mixtures, there did not appear to be a definite relation between viscosity and the absorptions or penetrations obtained. Thus in figure 2, the viscosities of the three mixtures of carbon-free tars and creosotes were about the same, although both penetrations and absorptions vary greatly. A comparison of the viscosities of the creosote-tar mixtures in Tables 4, 5, and 6, also indicates no apparent relation to the absorptions and penetrations when different tars are used.

TESTS OF THE EFFECT OF VARYING TIME, PRESSURE, AND TEMPERATURE.

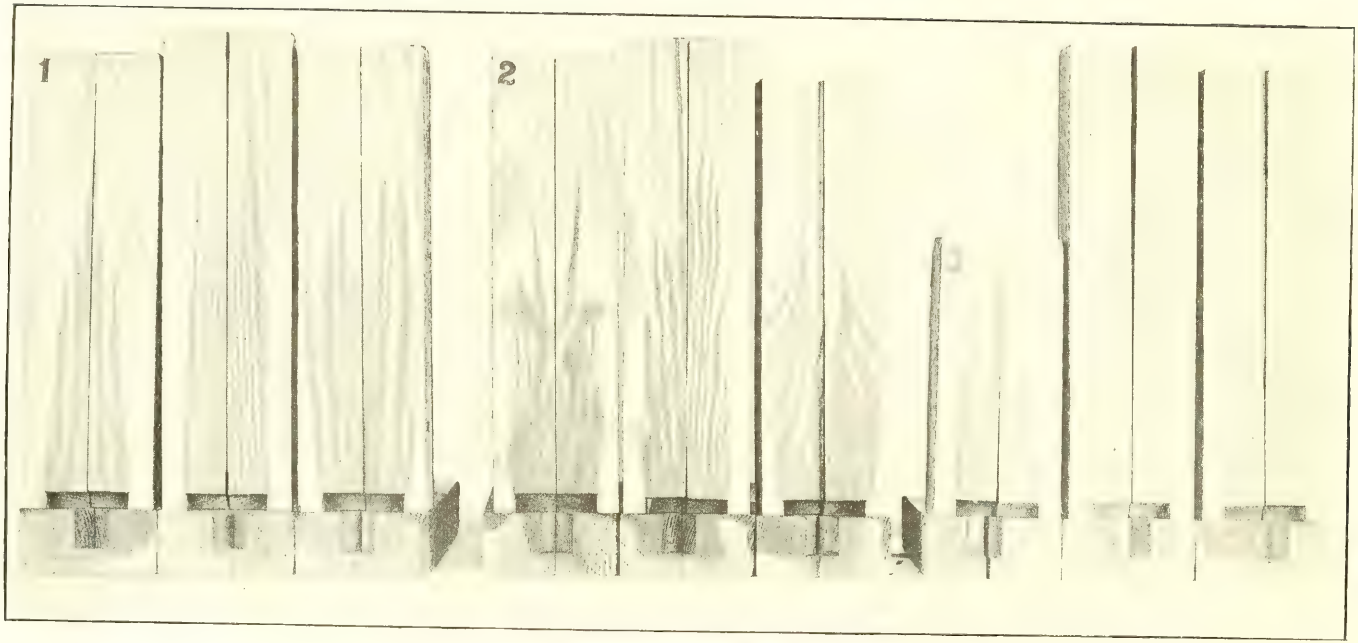
The results of the experiments described on page 7 indicate that in general the absorption and penetration of a tar and creosote mixture decreases as the amount of tar or free carbon in the mixture is

[1] Forestry Quarterly, March, 1913.



MATCHED SPECIMENS OF LONGLEAF PINE TREATED WITH VARIOUS COMMERCIAL CREOSOTES. (DATA IN TABLE 14, P. 36, AND TABLE D, P. 42.)

Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature, 160° F.



PENETRANCE SPECIMENS.

Group No. 1 treated with creosote. Group No. 2 treated with 80 per cent creosote, 20 per cent tar. Group No. 3 treated with 66⅔ per cent creosote, 33⅓ per cent tar. Specimens arranged in order of treatment as given in Table 15. Time of treatment, 2 hours; pressure, 80 pounds per square inch; temperature, 180° F.

increased, the conditions of treatment being constant. Experiments were made to determine the effect on the absorptions and penetrations of tar and creosote mixtures of an increase in the time of treatment, the intensity of the pressure, or the temperature of the pre-

PENETRANCE TESTS.

(Data in Table 14.)

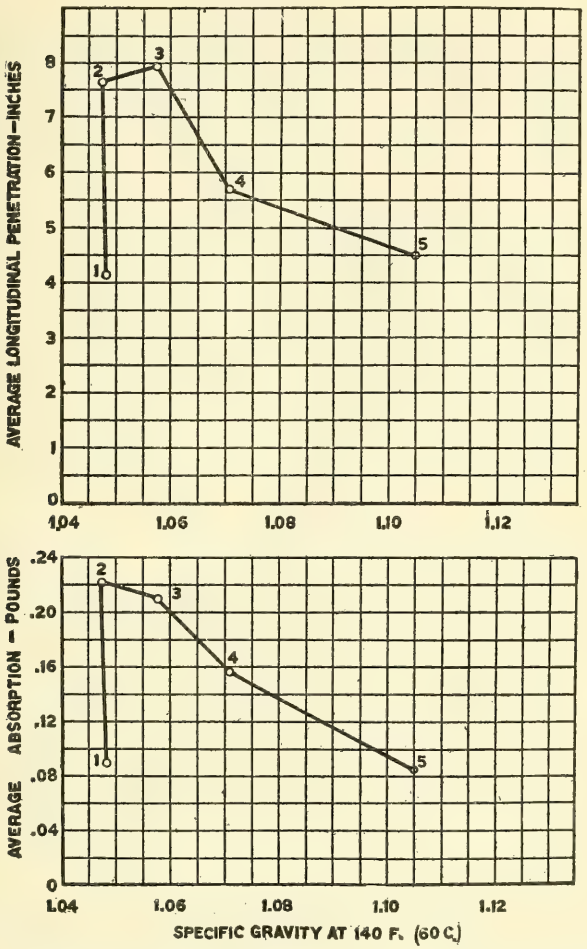


FIG. 6.—The relative absorptions and penetrations into longleaf pine of various commercial creosotes.

Point No.	Creosote No.	Kind of creosote.
1	1	Creosote containing tar (estimated at about 10 per cent).
2	2	Creosote.
3	3	Pure coal-tar creosote.
4	4	Creosote containing tar (estimated at less than 5 per cent).
5	5	High-boiling creosote.

Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature, 160° F.

servative. Two series of tests were made with the temperature and pressure of the preservative constant and the time of treatment varied to obtain the same absorption with the mixture as was obtained with the creosote unmixed with tar. Another series of tests was run, in which the pressure of the preservative was varied but the temperature and the time of treatment kept constant, and a comparison made of the pressures required to obtain the same absorption with various tar mixtures as was obtained with creosote unmixed with tar. A further series of tests was made in which the time of treatment, pressure of the preservative, and absorption were constant, but the temperature was varied. For comparison a test was made of the absorptions and penetrations obtained using the same time of treatment, temperature, and pressure of preservative for both the creosote unmixed with tar and for the tar mixtures.

The system of matching the penetrance specimens used in the experiments described on pages 4 to 20 was the same as that described on page 2, except that in one test four specimens were used and in other tests three specimens were used instead of two, as in the previous experiments. All of the blocks used in the impregnation tests were cut from the same stick and are, therefore, considered matched with each other.

PENETRANCE TESTS WITH COAL-TAR CREOSOTE NO. 6 AND BY-PRODUCT COKE-OVEN TAR NO. 4.

Time of treatment, temperature of preservative, and pressure constant.—(Table 15 and fig. 7.)

The first series of tests was made to study the relative absorptions and penetrations obtained with the creosote unmixed with tar; with mixtures of 80 per cent creosote and 20 per cent tar; and with $66\frac{2}{3}$ per cent creosote and $33\frac{1}{3}$ per cent tar. The pressure, the time of treatment, and the temperature of the preservative were the same for every preservative. These tests were made for comparison with those on the same mixtures where the pressure, time, etc., were varied. Details of the treatment are given in Table 15.

The average absorption and the average longitudinal penetration obtained with the 80 per cent creosote and 20 per cent tar mixture were each about 73 per cent of that obtained with the creosote. In the case of the $66\frac{2}{3}$ per cent creosote and $33\frac{1}{3}$ per cent tar mixture the absorption was about 66 per cent and the average longitudinal penetration about 69 per cent of that secured with creosote.

Temperature of preservative and pressure constant and the time of treatment varied.—(Tables 16 and 17 and fig. 8.)

With the mixture containing 20 per cent tar and 80 per cent creosote it was necessary to increase the treating period from two

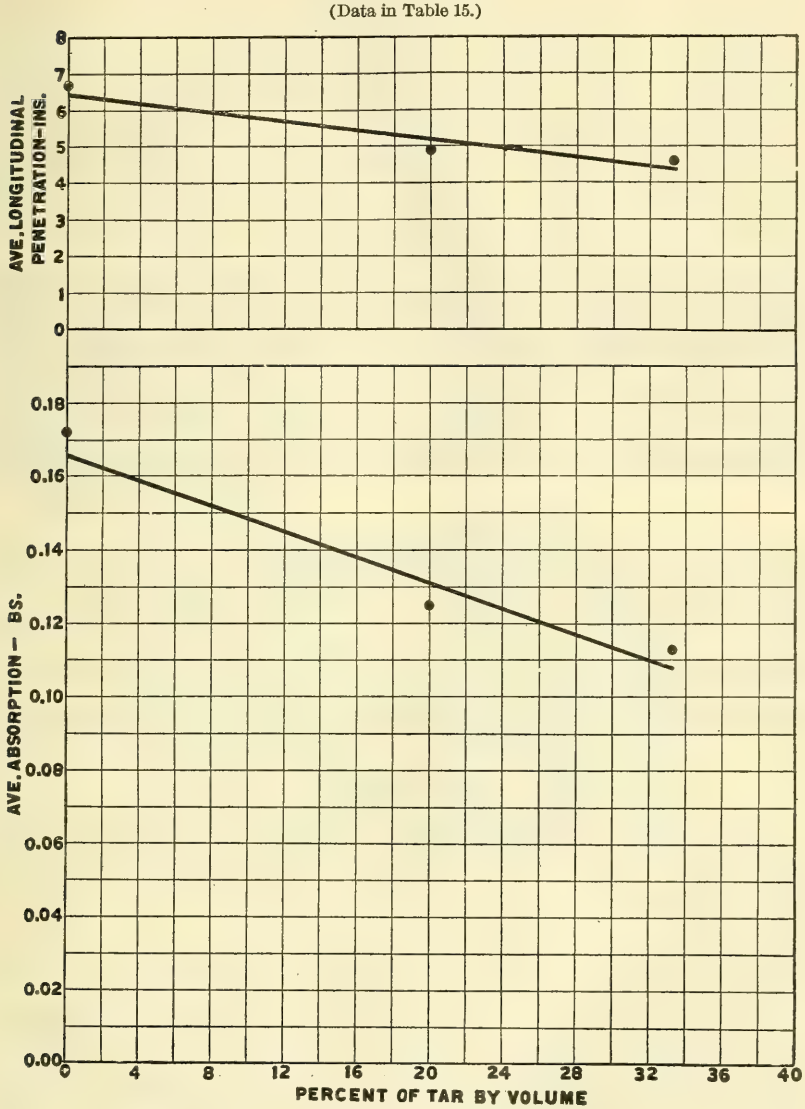


FIG. 7.—The relative absorptions and penetrations into longleaf pine using mixtures of creosote No. 6 and tar No. 4. Time of treatment, 2 hours; pressure, 80 pounds per square inch; temperature of preservative, 180° F.

hours to four hours to obtain the same absorption as when the creosote unmixed with tar was used. A reduction in the average

longitudinal penetration of about 17 per cent resulted from the increase in the proportion of tar.

When the mixture containing 33⅓ per cent of tar was used, it was noted that after the specimens had been treated for a certain length of time (see Table 15, footnote) no increase in the absorption was obtained. Hence it was not possible in this test (where the temperature of the preservative was 160° F. and the pressure 80 pounds per square inch) to obtain an absorption with the mixture equal to that obtained with the creosote, even when the time of treatment was increased to eight hours. The average longitudinal penetration was about 33 per cent less than obtained with the creosote.

PENETRANCE TESTS.

(Data in Tables 16 and 17.)

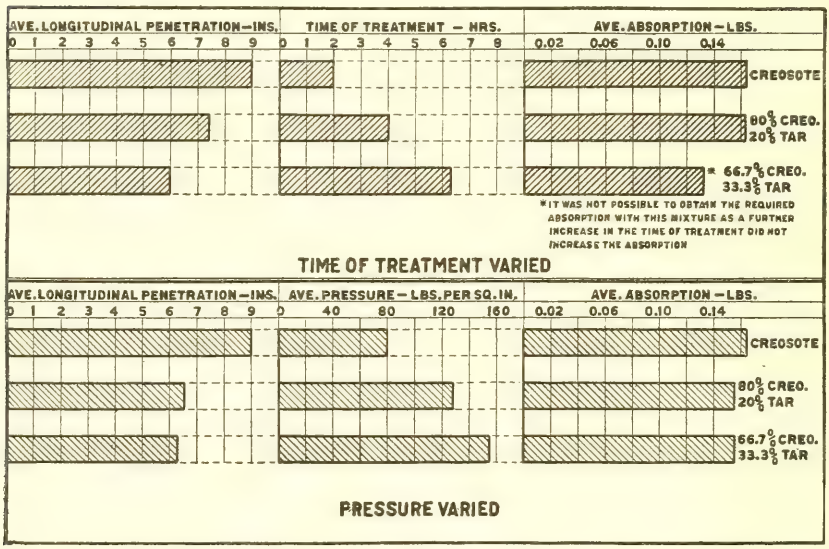
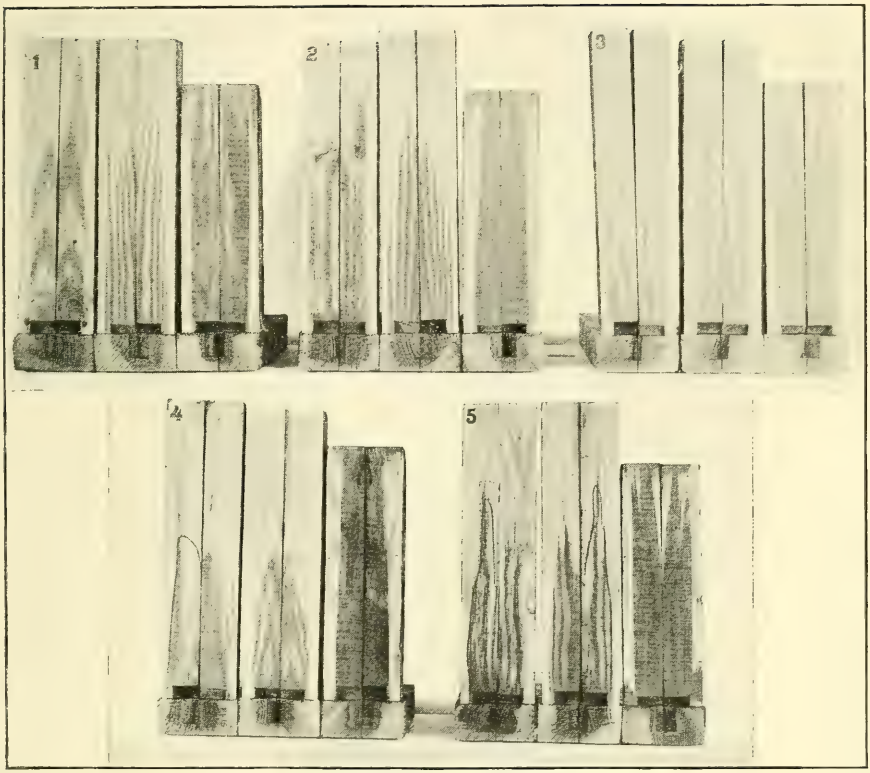


FIG. 8.—The relative effect of varying (1) time of treatment and (2) pressure in order to secure approximately the same absorption in longleaf pine using mixtures of tar No. 4 and creosote No. 6. With time varied the treating temperature was 160° F. and the pressure 80 pounds per square inch. With pressure varied the time of treatment was 2 hours and the temperature 160° F.

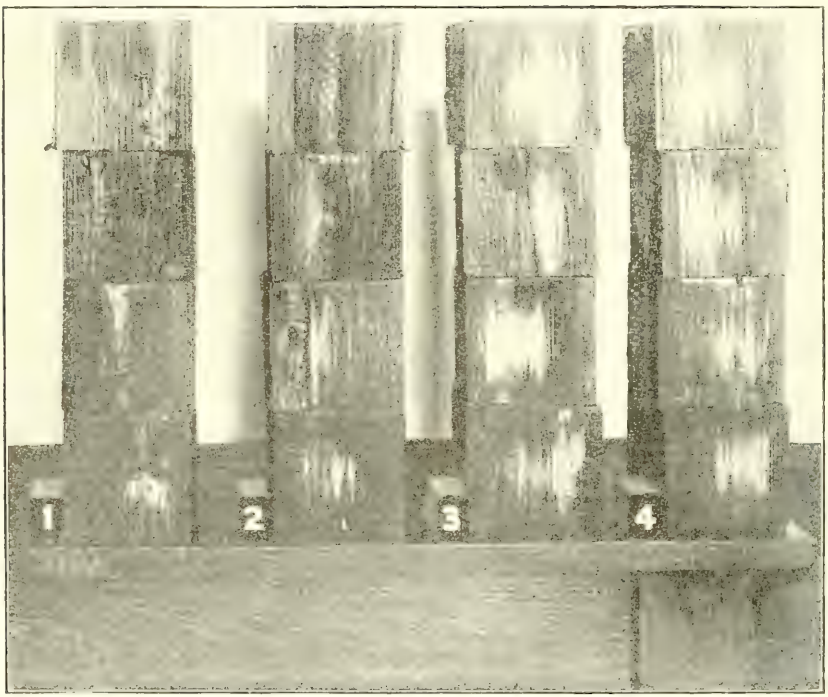
Time of treatment and temperature of preservative constant and pressure varied.—(Tables 16 and 17 and fig. 8.)

The specimens used in these tests were matched with those just preceding, and hence the results are directly comparable. The pressure required to obtain a given absorption in the test in which the temperature of the preservative and the time were constant was approximately proportional to the amount of the tar in the mixture. With almost the same absorption of preservative the penetrations of the two tar and creosote mixtures were from 27 to 29 per cent less than those obtained



PENETRANCE SPECIMENS.

Specimens arranged in order of treatment as given in Table 16. Group No. 1 treated with creosote. Time of treatment, 2 hours; pressure, 75 pounds per square inch; temperature, 180° F. Group No. 2 treated with 80 per cent creosote, 20 per cent tar. Time of treatment varied; temperature, 180° F. Group No. 3 treated with 66⅔ per cent creosote, 33⅓ per cent tar. Time of treatment varied; temperature, 180° F. Group No. 4 treated with 80 per cent creosote, 20 per cent tar. Pressure varied; temperature, 180° F. Group No. 5 treated with 66⅔ per cent creosote, 33⅓ per cent tar. Pressure varied; temperature, 180° F.



PENETRATION IN PAVING BLOCKS.

No. 1 blocks treated with creosote No. 4. No. 2 blocks treated with 75 per cent creosote No. 4 and 25 per cent tar No. 5. No. 3 blocks treated with 50 per cent creosote No. 4 and 50 per cent tar No. 5. No. 4 blocks treated with 25 per cent creosote No. 4 and 75 per cent tar No. 5.

with the creosote. Comparing these results with those in which the time of treatment was varied, it is noted that when the 20 per cent tar mixture was used better penetrations were obtained by lengthening the time of treatment than by increasing the pressure, the absorption being the same in both cases. This comparison can not properly be made with the mixture containing 33⅓ per cent tar, because the desired absorption was not obtained in this case when only the time of treatment was increased. (See note on fig. 8.)

IMPREGNATION TESTS.

(Data in Table 18.)

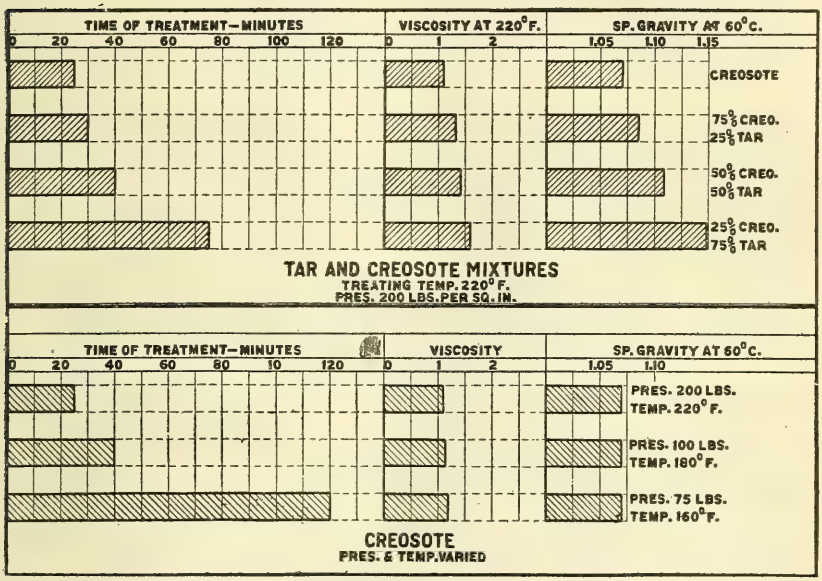


FIG. 9.—The time of treatment required to secure a given absorption in paving blocks using mixtures of creosote No. 4 and tar No. 5; also the increase in time of treatment required to secure a given absorption of creosote when the treating pressure and temperature were decreased.

IMPREGNATION TESTS WITH COAL-TAR CREOSOTE NO. 4 AND COAL-TAR NO. 5.

Temperature of preservative and pressure constant and time of treatment varied.—(Tables 19 and 20 and figs. 9 and 10.)

Tests to determine the effect of varying the time were made on matched paving-block specimens with mixtures containing 25 per cent tar and 75 per cent creosote, 50 per cent tar and 50 per cent creosote, and 75 per cent tar and 25 per cent creosote. Similar tests were made on penetrance specimens. (Fig. 10.) The creosote unmixed with tar was used for comparison. In these tests the time of treatment required to obtain a given absorption increased rapidly as the amount of tar in the mixture was increased, especially when 50 per cent and 75 per cent of tar were used. The desired absorption was obtained in the shortest time with creosote. In order to secure

approximately a corresponding absorption with the tar mixtures, the time of treatment was increased above that required for creosote by about 17 [1] per cent for the mixture containing 25 per cent tar, about 60 per cent for the mixture with 50 per cent tar, and 200 per cent for the mixture containing 75 per cent tar.

After treatment the blocks were split to determine the penetration. Those treated with creosote were completely penetrated, and those treated with the mixture containing 25 per cent tar were fairly well penetrated. A small area at the center of the blocks treated with mixtures having 50 and 75 per cent tar was unpenetrated. Plate X is a photograph of a set of these blocks when split.

PENETRANCE TESTS.

(Data in Table 19.)

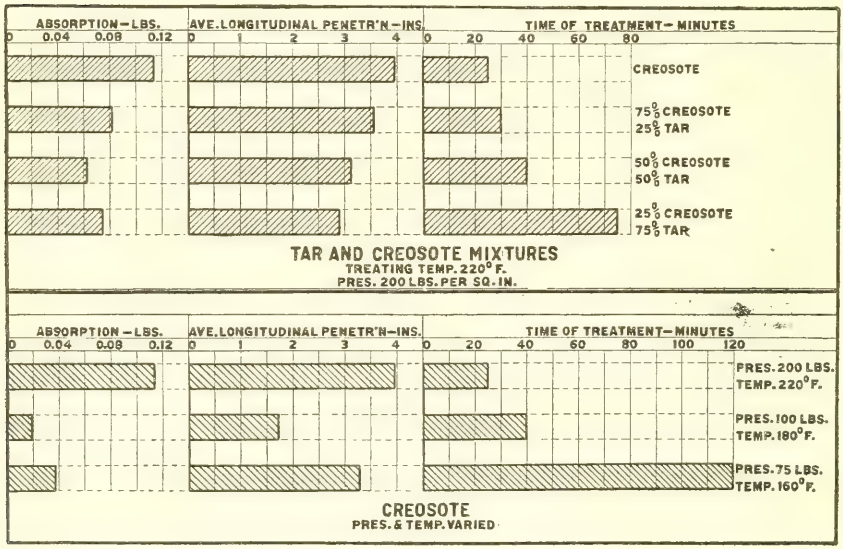


FIG. 10.—The relation between absorption, penetration, and time of treatment using mixtures of creosote No. 4 and tar No. 5; also the comparative effect of varying the pressure and time of treatment.

PENETRANCE TESTS WITH CREOSOTE NO. 4 AND TAR NOS. 1 AND 5.

Time of treatment and pressure constant and temperature varied.—(Tables 18 and 21 and figs. 11 and 12).

Two series of tests on the effect of varying the temperature were made, both on the penetrance apparatus. In the first series a mixture of 50 per cent creosote No. 4 and 50 per cent tar No. 1 was used. In the second, 75 per cent of tar No. 5 and 25 per cent of creosote No. 4 was used. Both the absorption and penetration were materially increased as the treating temperature was increased. The tests indicated that temperature is an important factor in absorption and

[1] Absorptions in these cases were about 9 per cent higher than with the creosote.

PENETRANCE TESTS.

(Data in Table 20.)

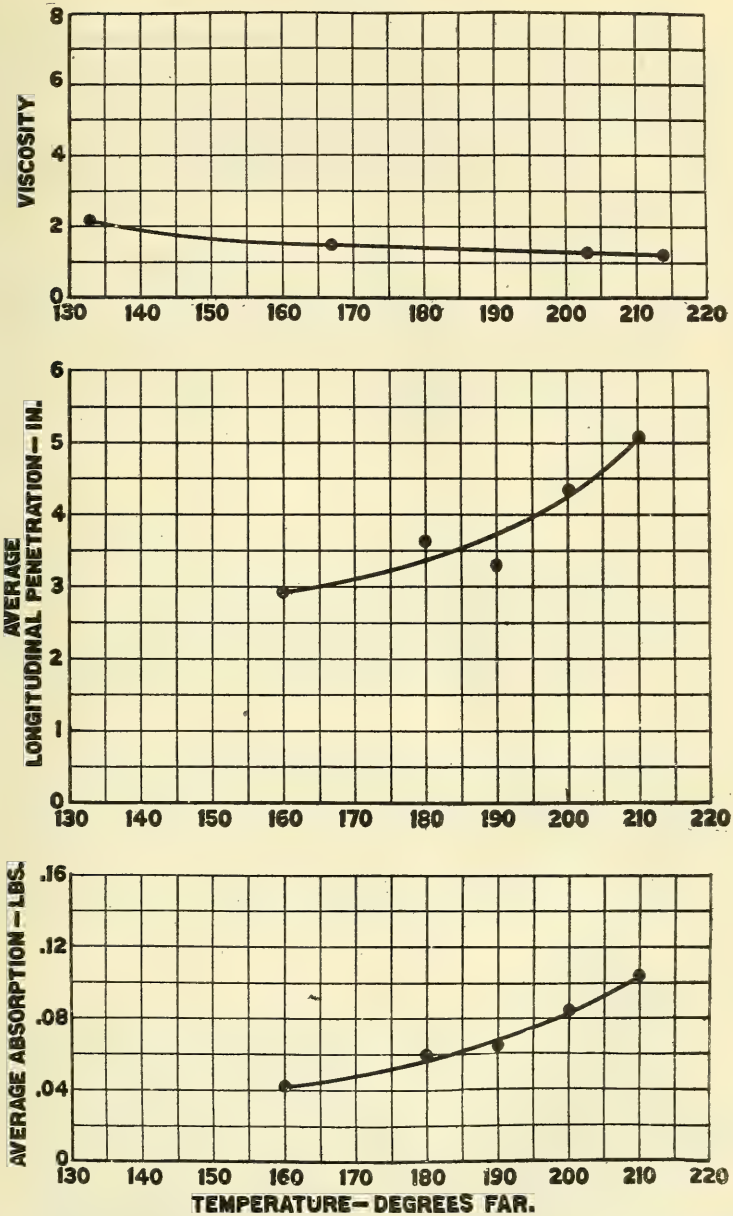


FIG. 11.—The relative absorptions and penetrations into longleaf pine of a mixture of equal parts of creosote No. 4 and a normal by-product coke-oven tar No. 1 at different temperatures (normal amount of free carbon in tar, 6 per cent, by weight). Time of treatment, 2 hours; pressure, 75 pounds per square inch.

penetration. Thus, in figure 11, the penetration at 210° F. was about two and one-half times that at 160° F., while the absorption

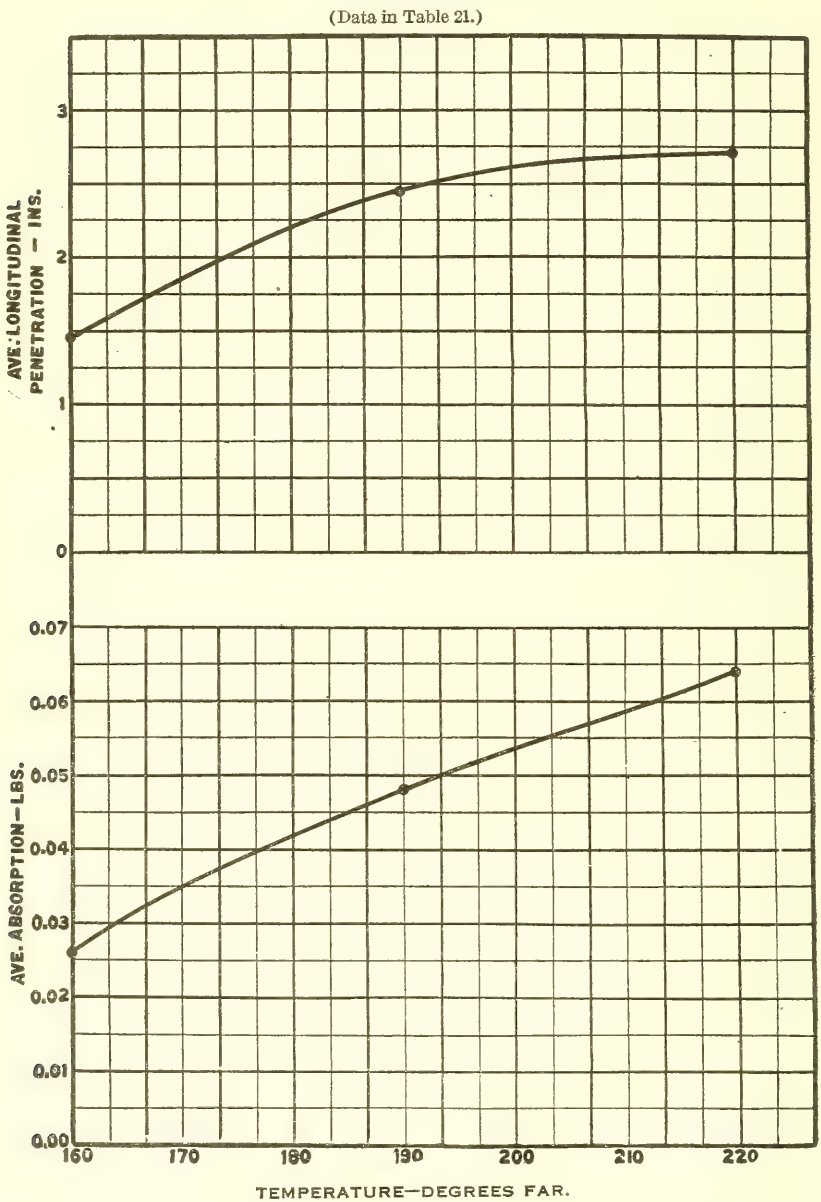
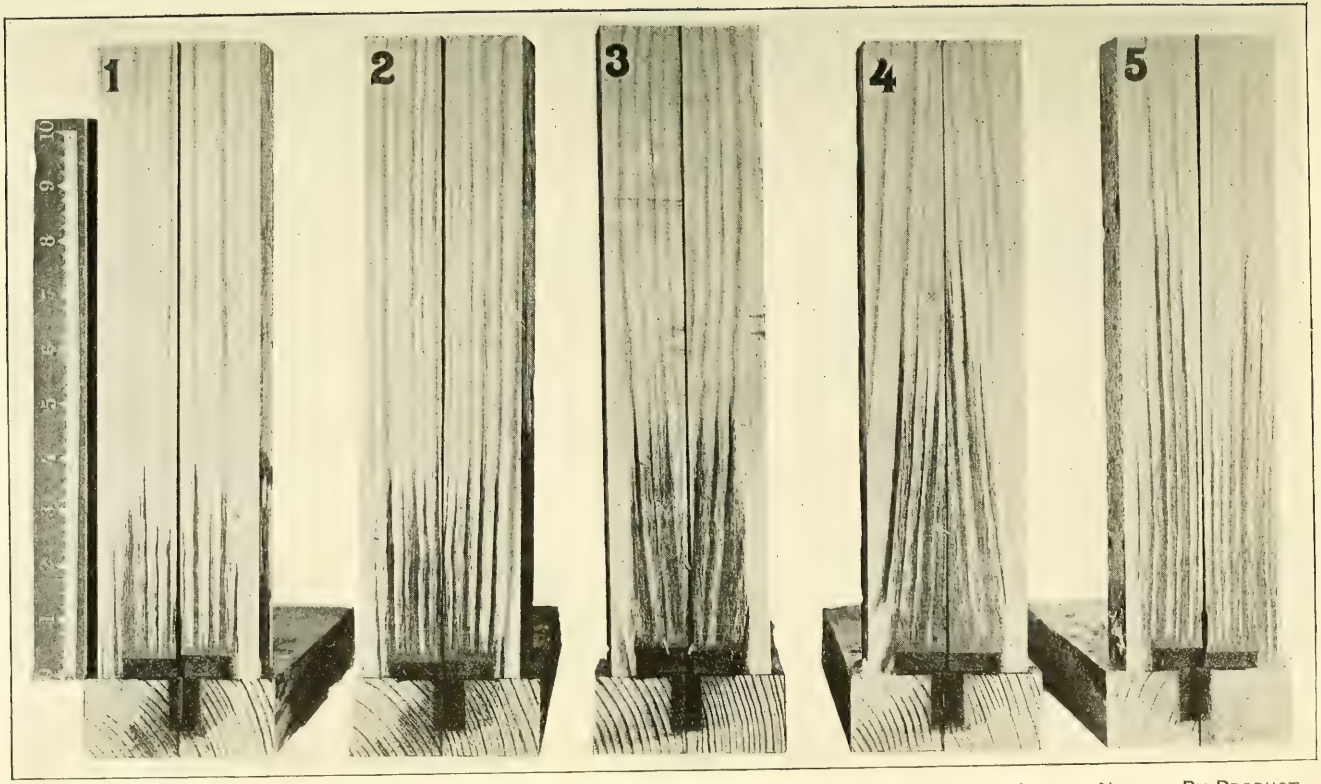


FIG. 12.—The relation between absorptions and penetrations into longleaf pine using a mixture of 25 per cent creosote No. 4 and 75 per cent tar No. 5 at different treating temperatures. Time of treatment, 1 hour; pressure, 200 pounds per square inch.

was 1.6 greater. In figure 12, with a mixture containing 75 per cent of tar, the penetration at 220° F. was also two and one-half times that at 160° F., while the absorption was twice as great.



MATCHED SPECIMENS OF LONGLEAF PINE TREATED WITH A MIXTURE OF EQUAL PARTS OF CREOSOTE NO. 4 AND A NORMAL BY-PRODUCT COKE-OVEN TAR NO. 1 AT DIFFERENT TEMPERATURES (NORMAL AMOUNT OF FREE CARBON IN TAR, 6 PER CENT, BY WEIGHT). (DATA IN TABLE 20, P. 42, AND TABLE E, P. 42.)

Time of treatment, 2 hours; pressure, 75 pounds per square inch.

SUMMARY.

The results of this investigation may be briefly summarized as follows:

The addition of coal tar to coal-tar creosote increased materially the difficulty of injection into heart longleaf pine. The resistance to impregnation was increased as the amount of tar was increased. Resistance to impregnation was greater to coal tars of high than to those of low free-carbon content. This was the case even when the free carbon was removed from these tars, indicating that the character of the bitumens as well as the free carbon influenced impregnation. The tests indicate that coal tars produced at relatively low temperatures penetrate better than those produced at relatively high temperatures. The size of the free-carbon particles was also found to be a factor in penetration, as those tars in which a large proportion of the particles were relatively small produced mats which were more nearly impervious to the passage of the preservative than those tars in which these particles were larger.

The relative viscosities of mixtures of coal tar creosote and coal tars from different sources are not necessarily a true index of their ability to penetrate wood. In these tests the viscosities of mixtures containing different tars did not appear to have any definite relation to the ease or difficulty of penetration.

For a mixture of a given tar and creosote the following three factors appear to be important in their relation to penetrations and absorptions:

1. The composition and character of the bitumens.
2. The amount of the free carbon in the tar.
3. The condition or size of the free carbon particles.

In the treatment of paving blocks the most general practice at present is to inject about 16 pounds of the preservative per cubic foot of wood. This absorption is not usually difficult to obtain in air-seasoned longleaf pine with coal tar creosote at relatively moderate pressures and temperatures, on account of the short length of the blocks (usually not over 4 inches). In these tests it was found that when coal tar was added to coal tar creosote, it was possible to obtain an absorption of 16 pounds per cubic foot by increasing the pressure, the temperature, and the time of treatment, the amount of the increase required depending upon the kind and amount of tar added. There was, however, a tendency to obtain less uniform penetrations with those mixtures containing the higher amounts of tar. Increasing the intensity of pressure was of greater importance in obtaining the desired absorption than increasing the time of treatment, while with a given absorption lengthening the time of treatment and using a

lower pressure gave better penetrations than shortening the time of treatment and increasing the pressure.

The temperature of the preservative was found to be very important. In the case of a mixture of tar and creosote containing 50 per cent of by-product coke-oven tar an increase in the temperature from 160° to 200° F. increased the absorption two and one-half times and penetration one and two-thirds times. A nearly similar result was obtained with another tar and creosote mixture containing 75 per cent of by-product coke-oven tar.

Since the tests were necessarily limited to a comparatively small number of tar and creosote mixtures and also to a small number of tests on each preservative, using only one species of wood, the relations brought out can not be considered as definitely established. The results may prove of value, however, in indicating some of the factors that bear an important relation to the injection of preservatives into wood.

In general, it might be expected from these results that if tar, either alone or in mixture with creosote, were used in the preservation of wood the difficulty of injection would increase as the percentage of tar and free carbon in the mixture was increased. The practice of filtering free carbon from tar and creosote mixtures, which is sometimes resorted to, would seem to offer a means of improving the penetrating properties of the preservative.

In these experiments those tars which contained normally the lower amounts of free carbon appeared to have better penetrating properties than those containing the higher amounts, even after the free carbon was removed. This suggests that mixtures containing low-carbon tars should prove easier to inject into the wood.

The results of the experiments in which the time of treatment, intensity of pressure, and temperature of the preservative were varied indicate that the pressure period should be as long as possible, the intensity of pressure being regulated to obtain the desired absorption, while the preservative should be at as high a temperature as it is practicable to work without injuring the wood. From 190° to 220° F. may be satisfactorily used in treating longleaf pine paving blocks.

The viscosity measurements made on the tar and creosote mixtures containing tar from different sources indicate that the viscosity may not always be a true index of the penetrating properties of the mixture and should probably not be relied upon for this purpose.

The quality of the wood used has a marked influence on the absorption and penetration. It has very frequently been observed that the springwood of rapid-growth southern pine is hard to penetrate. In general, better treatments may be obtained in wood which has narrow annual rings.

APPENDIX.

DETAILED DESCRIPTION OF TESTS.

Penetrance tests.—Each specimen before test was placed on a shelf in the oven of the penetrance apparatus and the temperature maintained at 160° F. for 24 hours.

A hole 1 inch in diameter and either $\frac{3}{4}$ or 1 inch deep was bored in the specimen. The piece was weighed to 0.001 of a pound immediately before and after treatment. The absorption of preservative by each specimen was determined from the difference in weights. About 24 hours after treatment each specimen was sawed longitudinally and transversely through the center of the hole on the lines indicated in figure 13. The treated areas shown on the surface thus exposed were measured by means of a planimeter and the average longitudinal penetrations determined from these measurements.

Impregnation tests.—The blocks were air-dried in the laboratory for several months; consequently they had a very small moisture content. Before treatment each block was weighed to 0.01 of a pound and the dimensions measured to 0.01 of an inch. The volume was

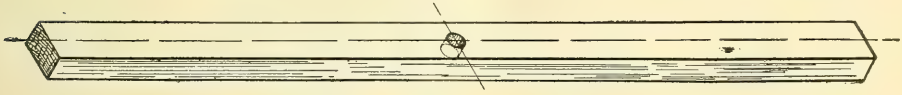


FIG. 13.—Appearance of test pieces.

determined from these measurements. After treatment each block was again weighed and the absorption in pounds per cubic foot computed.

APPARATUS.

The "penetrance apparatus," illustrated in figure 14, was designed for the penetrance tests. The wood under test, which had a 1-inch hole bored in it, figure 13, was clamped against the open end of the pipe A leading to the bottom of a pressure tank B. The pipe and lower portion of the tank were filled with the preservative. Pipe C, opening into the top of the tank, was connected with an air reservoir. When desired, air under pressure was turned into tank B, which thus placed the preservative under pressure. The apparatus was surrounded by a wooden oven R, with double glass windows in the front and back. Steam coils J in the bottom of the oven heated the specimens and preservatives to a uniform temperature, which duplicated as nearly as possible the temperature conditions of the treating cylinder. The pressure was determined from the gauge G and the temperature from thermometer H. A safety valve K aided in maintaining a uniform pressure. Shelves were provided and specimens were

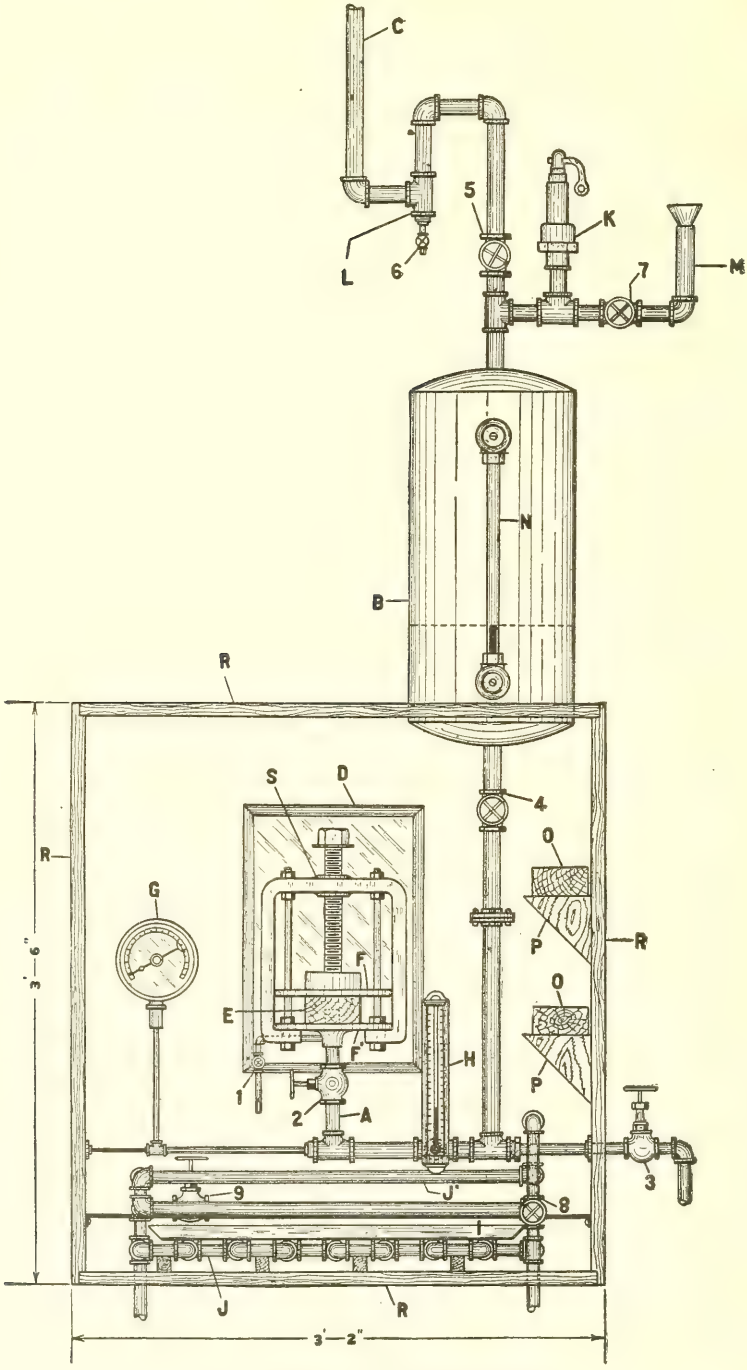


FIG. 14.—Apparatus for making penetrance tests.

placed in the apparatus previous to testing in order to heat them uniformly to the required temperature. By the aid of mirror D, placed at the back of the oven, both ends of the specimens were made visible.

In making the impregnation treatments on the paving-block specimens, small treating cylinders were used. The tests of the effect on penetration of differences in the preservative were made in a cylinder 6 inches in diameter and 12 inches deep which was substituted for the clamping device in the penetrance apparatus. Other impregnation tests were made in a 1½-foot by 4-foot treating cylinder.

METHOD OF OBTAINING CARBON-FREE TAR.

The free carbon was removed from a portion of tars Nos. 1, 2, and 3, as follows:

The tar was first dissolved in chloroform and the mixture then passed through a single thickness of fine quantitative filter paper. This process of filtration was repeated on the mixture using fresh filter papers each time, until no residue was deposited on the paper after the final filtering. The residue left on the papers was boiled in chloroform to dissolve any of the soluble tar constituents that might be deposited with the free carbon. This mixture was also filtered a number of times until no appreciable residue was left on the filter papers. The chloroform was then distilled off from the two mixtures which were combined and considered to be carbon-free tar. Analyses and coking tests were made which indicated that the material extracted was nearly all free carbon.

DETERMINATION OF FREE CARBON IN TARS.

The percentage of free carbon in each of the tars was determined to the nearest one-half of 1 per cent by careful quantitative filtering, employing a heavily matted Gooch crucible. After filtration was practically completed, the residue in the crucible was washed with chloroform until there was no further coloration of the liquid.

SPECIFIC GRAVITIES.

Specific gravities were determined by means of a Westphal balance. These determinations were accurate to one in the third decimal place for creosote and most of the mixtures of tar and creosote, and to two or three in the third decimal place for the heaviest tars.

VISCOSITIES.

The viscosities were determined by means of an Engler viscosimeter, which was standardized with water at 20° C.

Analyses of creosotes used in the experiments.

Creosote No. 1.—The distillation is as follows:

Temperature.	Distillation.
°C.	*Per cent.*
205	11.0
235	28.3
245	5.1
275	9.7
305	13.1
320	6.9
Residue	25.8
Loss	0.1
Total	100.0

Specific gravity, 1.0483 at 60° C. The index of refraction values are low for coal-tar creosote, and the water content is high, being 8.4 per cent of the original oil. The residue indicates the presence of undistilled tar, probably about 10 per cent.

Creosote No. 2.—The distillation is as follows:

Temperature.	Distillation.
°C.	*Per cent.*
205	6.8
235	40.0
245	4.5
275	13.4
305	11.0
Residue	24.1
Loss	0.2
Total	100.0

Specific gravity, 1.0475 at 60° C. The distillation curve and the index of refraction values for the most part fall within the range ascribed to a pure coal-tar creosote, but there is a decided tendency in the index of refraction values for the higher fractions, which indicates the presence of petroleum-like substances.

Creosote No. 3.—The distillation is as follows:

Temperature.	Distillation.
°C.	*Per cent.*
205	4.6
235	27.4
245	5.1
285	21.3
305	11.6
360	22.7
Residue	7.0
Loss	0.3
Total	100.0

Specific gravity, 1.0576 at 60° C. The index of refraction values and the distillation curve indicate that the oil is a pure coal-tar creosote.

Creosote No. 4.—The distillation is as follows:

Temperature.	Distillation.
°C.	*Per cent.*
205	1.2
235	22.7
245	5.7
275	9.9
305	11.5
360	27.6
Residue	20.9
Loss	0.5
Total	100.0

Specific gravity, 1.071 at 60° C. The indices of refraction at 60° C. are very low for a pure coal-tar creosote. The sulphonation values are low, yet are an indication of the presence of petroleum oils. The residue is a soft sticky pitch and indicates the presence of undistilled tar probably less than 5 per cent. From the appearance and physical properties of the fractions the creosote behaves very much like a mixed creosote.

Creosote No. 5.—The distillation is as follows:

Temperature.	Distillation.
°C.	*Per cent.*
205	1.3
235	2.2
245	1.8
275	7.1
305	14.2
360	40.4
Residue	32.8
Loss	0.2
Total	100.0

Specific gravity, 1.105 at 60° C. The index of refraction values are almost entirely in the range for mixed creosotes. The sulphonation residues do not indicate the presence of paraffine oils. The nature of the residue is not such as to show the presence of undistilled tar. The appearance and physical properties of the fractions indicate a high boiling creosote oil.

Creosote No. 6.—The distillation is as follows:

Temperature.	Distillation.
°C.	*Per cent.*
180	2.0
235	37.7
245	5.2
275	9.5
305	11.7
330	8.6
Residue	25.0
Loss	0.3
Total	100.0

Specific gravity, 1.047 at 60° C. The index of refraction values lie mostly in the range for mixed creosotes. The sulphonation residues are too high for a straight coal-tar creosote and their character is much like that of petroleum oils. The amount of residue above 330° is rather large, but there is no sign of undistilled tar in it.

TABLE 1.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of creosote No. 4 and carbon-free by-product coke-oven tar No. 1 (normal amount of free carbon in tar, 6 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar No. 1.	Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.)	Viscosity at 160° F. (Engler viscosimeter).			
		P. ct. by volume.	*P. ct. by volume.*	*P. ct. by weight.*			*Lbs.*	*Lbs.*	*Ins.*
19A	13.0	0	100	Trace.	1.071	1.2	4.970	0.250	7.00
35	17.5	0	100	Trace.	1.071	1.2	4.270	.195	6.05
Average	15.3							.223	6.53
28	12.0	25	75	Trace.	1.102	1.4	4,783	.168	5.00
23A	14.5	25	75	Trace.	1.102	1.4	4.800	.266	7.64
Average	13.3							.217	6.32
32	15.0	50	50	Trace.	1.127	1.6	4.458	.122	4.34
22A	15.0	50	50	Trace.	1.127	1.6	4.825	.107	4.44
Average	15.0							.115	4.39
29	11.5	75	25	Trace.	1.150	2.3	4.504	.090	3.25
24A	13.0	75	25	Trace.	1.150	2.3	4.677	.119	4.05
Average	12.3							.105	3.65
30	13.5	100	0	Trace.	1.182	3.6	4.566	.069	4.19
20A	16.5	100	0	Trace.	1.182	3.6	4.463	.055	2.76
Average	15.0							.062	3.48

Average moisture in specimens about 2 per cent.

TABLE 2.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of creosote No. 4 and carbon-free by-product coke-oven tar No. 2 (normal amount of free carbon in tar, 16 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar No. 2.	Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.)	Viscosity at 160° F. (Engler viscosimeter).			
		P. ct. by volume.	*P. ct. by volume.*	*P. ct. by weight.*			*Lbs.*	*Lbs.*	*Ins.*
C-6	13.0	0	100	Trace.	1.071	1.2	4.059	0.241	7.31
B-5	15.0	0	100	Trace.	1.071	1.2	4.506	.139	4.25
Average	14.0							.190	5.78
C-4	13.0	25	75	Trace.	1.105	1.4	4.132	.103	3.89
B-6	14.0	25	75	Trace.	1.105	1.4	4.237	.167	4.71
Average	13.5							.135	4.30
C-5	14.5	50	50	Trace.	1.132	1.7	4.109	.111	4.34
B-3	14.0	50	50	Trace.	1.132	1.7	4.220	.089	3.68
Average	14.3							.100	4.01
C-3	11.0	75	25	Trace.	1.163	2.2	4.175	.041	2.71
B-2	13.0	75	25	Trace.	1.163	2.2	4.185	.033	1.90
Average	12.0							.037	2.31
C-2	9.0	100	0	Trace.	1.215	3.1	4.216	.035	1.25
B-1	16.0	100	0	Trace.	1.215	3.1	3.070	.021	1.42
Average	12.5							.028	1.34

Average moisture in specimens about 4.5 per cent.

TABLE 3.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of creosote No. 4 and carbon-free gas-house tar No. 3 (normal amount of free carbon in tar, 30 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar No. 3.	Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.)	Viscosity at 160° F. (Engler viscosimeter).			
		Per cent by volume.	*Per cent by volume.*	*Per cent by weight.*			*Lbs.*	*Lbs.*	*Ins.*
A-F-4	21.0	0	100	Trace.	1.071	1.2	4.272	0.117	5.55
A-E-3	21.0	0	100	Trace.	1.071	1.2	4.124	.121	4.65
Average	21.0							.119	5.10
A-F-2	20.0	25	75	Trace.	1.097	1.4	4.219	.054	3.62
A-E-6	22.0	25	75	Trace.	1.097	1.4	4.626	.054	3.20
Average	21.0							.054	3.41
A-F-1	20.0	50	50	Trace.	1.127	1.6	3.855	.015	1.60
A-E-7	20.0	50	50	Trace.	1.127	1.6	3.750	.014	1.43
Average	20.0							.015	1.52
A-F-5a	21.0	75	25	Trace.	1.148	2.3	2.063	.010	1.00
A-E-5a	19.0	75	25	Trace.	1.148	2.3	2.096	.011	1.15
Average	20.0							.011	1.08
A-E-2a	20.0	100	0	Trace.	1.179	3.8	1.697	.012	1.15
A-F-3a	22.0	100	0	Trace.	1.179	3.8	1.990	.007	.75
Average	21.0							.010	.95

Average moisture in specimens about 9 per cent.

TABLE 4.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of equal parts of creosote No. 4 and three different carbon-free and normal free-carbon tars.*

Specimen No.	Average number annual rings per inch.	Character of preservative.						Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar Nos. 1, 2, and 3.		Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.)	Viscosity at 160° F. (Engler vicosimeter).			
		By volume.	Free carbon normal to tar.							
		Per cent.	*Per cent.*	*Per cent by volume.*	*Per cent by weight.*			*Lbs.*	*Lbs.*	*Ins.*
II-3	24.0	50	6	50	Trace.	1.127	1.6	1.443	0.127	3.75
III-2	18.0	50	6	50	Trace.	1.127	1.6	2.826	.200	4.19
Average	21.0								.164	3.97
II-8	17.0	50	16	50	Trace.	1.132	1.7	3.450	.130	4.30
III-5	20.0	50	16	50	Trace.	1.132	1.7	3.185	.080	3.12
Average	18.5								.105	3.71
II-5	22.0	50	30	50	Trace.	1.127	1.6	3.010	.053	2.27
III-4	17.0	50	30	50	Trace.	1.127	1.6	2.660	.076	2.18
Average	19.5								.065	2.23
II-2-B	18.0	50	6	50	3.0	1.132	1.7	1.420	.038	2.05
III-2-B	24.0	50	6	50	3.0	1.132	1.7	1.386	.054	2.00
Average	21.0								.046	2.03
II-1-A	22.0	50	16	50	8.0	1.159	2.6	1.410	.043	2.28
III-6-B	15.0	50	16	50	8.0	1.159	2.6	1.452	.029	1.54
Average	18.5								.036	1.91
II-4-A	21.0	50	30	50	15.0	1.166	2.5	1.466	.027	1.15
III-2-A	18.0	50	30	50	15.0	1.166	2.5	1.318	.017	1.13
Average	19.5								.022	1.14

Average moisture in specimens about 8 per cent.

TABLE 5.—*Treatment of paving blocks with mixtures of creosote No. 4 and carbon-free tar No. 1.*

Block tag No.	Dimensions of block.	Weight before treatment.	Preservative absorbed.	Preservative used.	Pressure.	Time of treatment.	Product of pressure by time.
	Inches.	*Pounds.*	*Pounds per cubic foot.*		*Pounds per square inch.*	*Hours.*	
1	7.65 by 3.82 by 4.0	2.685	16.8	Creosote	80	2	140
32	8.10 by 3.65 by 4.0	2.715	15.4	Creosote	80	3	220
Average			16.1				180
11	7.75 by 3.80 by 4.0	2.826	17.7	75 per cent creosote, 25 per cent tar.	80	$2\frac{1}{2}$	180
56	8.10 by 3.50 by 4.2	2.820	13.5	75 per cent creosote, 25 per cent tar.	80	$3\frac{1}{2}$	260
Average			15.6				220
26	7.95 by 3.62 by 4.0	2.560	14.3	50 per cent creosote, 50 per cent tar.	80	6	460
7	7.75 by 3.55 by 4.0	2.665	19.1	50 per cent creosote, 50 per cent tar.	80	4	300
Average			16.7				380
43	7.65 by 3.80 by 4.0	2.680	14.8	25 per cent creosote, 75 per cent tar.	(1)	$5\frac{1}{2}$	490
10	8.20 by 3.55 by 4.15	2.850	13.7	25 per cent creosote, 75 per cent tar.	(2)	6	565
Average			14.3				527
41	7.67 by 3.05 by 4.03	2.170	16.7	100 per cent tar	(2)	6	565
58	8.10 by 3.60 by 4.0	2.670	14.1	100 per cent tar	(3)	$6\frac{1}{2}$	640
Average			15.4				602

[1] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; ½ hour at 150 pounds.
[2] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 1 hour at 150 pounds.
[3] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 1½ hours at 150 pounds.

In all tests ½ hour was taken to obtain pressure up to 80 pounds.

TABLE 6.—*Treatment of paving blocks with mixtures of creosote No. 4 and carbon-free tar No. 2.*

Block tag No.	Dimensions of block.	Weight before treatment.	Preservative absorbed.	Preservative used.	Pressure.	Time of treatment.	Product of pressure by time.
	Inches.	*Pounds.*	*Pounds per cubic foot.*		*Pounds per square inch.*	*Hours.*	
21	7.65 by 3.80 by 4.0	2.880	17.4	75 per cent creosote, 25 per cent tar.	80	3	220
22	8.05 by 3.62 by 4.0	2.655	13.7	75 per cent creosote, 25 per cent tar.	80	$4\frac{1}{2}$	340
Average			15.6				280
23	7.75 by 4.0 by 4.0	2.970	17.6	50 per cent creosote, 50 per cent tar.	80	$5\frac{1}{2}$	420
60	8.00 by 4.2 by 3.5	2.780	14.7	50 per cent creosote, 50 per cent tar.	(1)	6	565
Average			16.2				492
37	7.75 by 3.90 by 4.0	3.090	14.5	25 per cent creosote, 75 per cent tar.	(1)	5	415
4	8.15 by 3.60 by 4.0	2.720	13.2	25 per cent creosote, 75 per cent tar.	(2)	$6\frac{1}{2}$	640
Average			13.9				527
5	7.70 by 3.95 by 4.0	2.955	19.4	100 per cent tar	(3)	$5\frac{3}{4}$	527
0	8.20 by 3.58 by 4.0	2.880	14.1	100 per cent tar	(4)	7	715
Average			16.8				621

[1] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 1 hour at 150 pounds.
[2] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 1½ hours at 150 pounds.
[3] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; ¾ hour at 150 pounds.
[4] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2 hours at 150 pounds.

In all tests ½ hour was taken to obtain pressure up to 80 pounds.

TABLE 7.—*Treatment of paving blocks with mixtures of creosote No. 4 and carbon-free gas-house tar No. 3.*

Block tag No.	Dimensions of block.	Weight before treatment.	Preservative absorbed.	Preservative used.	Pressure.	Time of treatment.	Product of pressure by time.
	Inches.	*Pounds.*	*Pounds per cubic foot.*		*Pounds per square inch.*	*Hours.*	
3	7.71 by 3.77 by 4.0	2.770	16.1	75 per cent creosote, 25 per cent tar.	80	3½	260
34	8.15 by 3.62 by 4.15	2.820	12.4		80	4½	340
Average			14.3				300
57	7.75 by 3.45 by 4.0	2.580	19.0	50 per cent creosote, 50 per cent tar.	(1)	6½	640
52	8.15 by 3.55 by 4.2	2.880	12.2		(2)	7	715
Average			15.6				677
9	7.75 by 3.85 by 4.0	2.920	17.0	25 per cent creosote, 75 per cent tar.	(2)	7	715
44	8.15 by 3.60 by 4.1	2.855	9.6		(3)	7½	790
Average			13.3				752
29	7.75 by 3.10 by 4.0	2.335	18.6	100 per cent tar	(4)	7¾	827
6	7.95 by 3.60 by 4.0	2.660	11.9		(5)	8	865
Average			15.2				846

[1] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 1½ hours at 150 pounds.
[2] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2 hours at 150 pounds.
[3] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2½ hours at 150 pounds.
[4] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2¾ hours at 150 pounds.
[5] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 3 hours at 150 pounds.

In all tests ½ hour was taken to obtain pressure up to 80 pounds.

TABLE 8.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of equal parts of creosote No. 4 and by-product coke-oven tar No. 1 with different amounts of free carbon (normal amount of free carbon in tar, 6 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar No. 1.	Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.).	Viscosity at 160° F. (Engler viscosimeter).			
		P. ct. by volume.	*P. ct. by volume.*	*P. ct. by weight.*			*Lbs.*	*Lbs.*	*Ins.*
K-4	22.0	50	50	Trace.	1.127	1.6	4.008	.200	5.20
R-5	15.0	50	50	Trace.	1.127	1.6	3.444	.151	3.98
Average	18.5							.176	4.89
K-6	23.0	50	50	1	1.128	1.7	4.180	.122	4.55
R-2	17.0	50	50	1	1.128	1.7	3.250	.130	3.50
Average	20.0							.126	4.03
K-3	21.0	50	50	1.5	1.129	1.7	3.616	.100	3.97
R	16.0	50	50	1.5	1.129	1.7	1.444	.087	2.73
Average	18.5							.094	3.35
K-7	21.0	50	50	2.5	1.130	1.5	4.390	.098	3.82
R-3	16.0	50	50	2.5	1.130	1.5	3.312	.078	2.80
Average	18.5							.088	3.31
K-5	20.0	50	50	3	1.132	1.7	4.095	.063	3.12
R-7	16.0	50	50	3	1.132	1.7	3.783	.060	2.73
Average	18.0							.062	2.93

Average moisture in specimens about 11 per cent.

TABLE 9.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of equal parts of creosote No. 4 and by-product coke-oven tar No. 2 containing different amounts of free carbon (normal amount of free carbon in tar, 16 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar No. 2.	Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.)	Viscosity at 160° F. (Engler viscosimeter).			
		P. ct. by volume.	*P. ct. by volume.*	*P. ct. by weight.*			*Lbs.*	*Lbs.*	*Ins.*
F-4	16.5	50	50	Trace.	1.132	1.7	4.021	0.071	2.61
G-5	15.0	50	50	Trace.	1.132	1.7	4.115	.025	1.39
Average	15.8							.048	2.00
F-1	17.0	50	50	3	1.140	1.9	4.178	.064	2.82
G-2	16.0	50	50	3	1.140	1.9	4.376	.016	1.10
Average	16.5							.040	1.96
F-3	16.0	50	50	5	1.147	1.9	4.123	.049	2.45
G-1	16.5	50	50	5	1.147	1.9	4.280	.012	.80
Average	16.3							.031	1.63
F-7	16.0	50	50	6.5	1.152	2.0	4.198	.050	2.43
G-3	17.0	50	50	6.5	1.152	2.0	4.315	.009	.80
Average	16.5							.029	1.62
F-6	17.0	50	50	8	1.159	2.6	4.135	.047	2.00
G-7	16.0	50	50	8	1.159	2.6	[1]1.673	.008	1.15
Average	16.5							.027	1.58

[1] Short specimen.

Average moisture in specimens about 5 per cent.

TABLE 10.—*Data upon the relative absorptions and penetrations into longleaf pine of mixtures of equal parts of creosote No. 4 and tar No. 3 containing different amounts of free carbon (normal amount of free carbon in tar, 30 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		Tar No. 3.	Creosote No. 4.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.).	Viscosity at 160° F. (Engler viscosimeter).			
		P. ct. by volume.	*P. ct. by volume.*	*P. ct. by weight.*			*Lbs.*	*Lbs.*	*Ins.*
II-7	14.0	50	50	Trace.	1.127	1.6	[1]1.580	.053	3.16
H-4	15.0	50	50	Trace.	1.127	1.6	4.187	.029	2.82
Average	14.5							.041	2.99
II-5	14.0	50	50	4.5	1.133	1.7	4.665	.045	2.30
H-1	12.0	50	50	4.5	1.133	1.7	[1]1.667	.023	1.69
Average	13.0							.034	2.00
II-4	12.0	50	50	6	1.142	1.9	4.453	.019	2.25
H-7	12.0	50	50	6	1.142	1.9	4.357	.007	1.13
Average	12.0							.013	1.69
II-4A	12.0	50	50	8	1.146	2.0	[1]1.704	.031	1.50
H-6	13.0	50	50	8	1.146	2.0	4.097	.010	1.25
Average	12.5							.021	1.38
II-7A	14.0	50	50	12	1.152	2.5	4.407	.037	2.54
H-5	13.5	50	50	12	1.152	2.5	4.040	.007	1.18
Average	13.8							.022	1.86
II-3	14.0	50	50	15	1.166	2.5	[1]1.826	.038	3.00
H-3	13.0	50	50	15	1.166	2.5	1.664	.016	1.39
Average	13.5							.027	2.20

[1] Short specimens.

Average moisture in specimens about 6 per cent.

TABLE 11.—*Treatments of paving blocks with 50 per cent creosote No. 4 and 50 per cent tar No. 1 having varying percentages of carbon.*

Block tag No.	Dimensions of block.	Weight before treatment.	Preservative absorbed.	Preservative used.	Pressure.	Time of treatment.	Product of pressure by time.
	Inches.	*Pounds.*	*Pounds per cubic feet.*		*Pounds per square inch.*	*Hours.*	
19	7.70 by 3.75 by 4.0	2.830	15.0	50 per cent creosote	80	4	300
30	8.15 by 3.50 by 4.2	2.860	14.8	50 per cent tar with 1½ per cent carbon.	([1])		495
Average			14.9				397
49	7.70 by 3.84 by 4.0	2.855	16.2	50 per cent creosote	80	5	380
54	8.20 by 3.60 by 4.15	2.900	15.2	50 per cent tar with 3 per cent carbon.	([2])	5½	490
Average			15.7				435

[1] Five hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds.
[2] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; one-half hour at 150 pounds.

In all tests one-half hour was taken to obtain pressure up to 80 pounds.

TABLE 12.—*Treatment of paving blocks with 50 per cent creosote No. 4 and 50 per cent tar No. 2 having varying percentages of carbon.*

Block tag No.	Dimensions of block.	Weight before treatment.	Preservative absorbed.	Preservative used.	Pressure.	Time of treatment.	Product of pressure by time.
	Inches.	*Pounds.*	*Pounds per cubic feet.*		*Pounds per square inch.*	*Hours.*	
35	7.65 by 3.80 by 4.0	2.760	16.1	50 per cent creosote.	80	6	460
38	8.15 by 3.60 by 4.0	2.740	15.3	50 per cent tar with 5 per cent carbon.	[1]	6½	640
Average			15.7				550
33	7.65 by 3.80 by 4.0	2.750	17.7	50 per cent creosote.	[2]	5	415
48	8.10 by 3.62 by 4.0	2.690	14.9	50 per cent tar with 10 per cent carbon.	[3]	7½	790
Average			16.3				602
2	8.15 by 3.62 by 4.0	2.790	16.5	50 per cent creosote.	[4]	8	865
39	7.68 by 3.80 by 4.0	2.760	16.8	50 per cent tar with 16 per cent carbon.	80	5½	420
Average			16.7				642

In all tests one-half hour was taken to obtain pressure up to 80 pounds.

[1] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 1½ hours at 150 pounds.
[2] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds.
[3] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2½ hours at 150 pounds.
[4] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 3 hours at 150 pounds.

TABLE 13.—*Treatment of paving blocks with 50 per cent creosote No. 4 and 50 per cent tar No. 3 having varying percentages of carbon.*

Block tag No.	Dimensions of block.	Weight before treatment.	Preservative absorbed.	Preservative used.	Pressure.	Time of treatment.	Product of pressure by time.
	Inches.	*Pounds.*	*Pounds per cubic feet.*		*Pounds per square inch.*	*Hours.*	
27	7.70 by 3.85 by 4	3.150	17.2	50 per cent creosote.	[1]	7	715
20	8.20 by 3.55 by 4	3.180	13.9	50 per cent tar with 9 per cent carbon.	[2]	7½	790
Average			15.6				752
15	7.75 by 3.85 by 4	3.220	18.5	50 per cent creosote.	[2]	7½	790
50	8.13 by 3.62 by 4	2.700	10.3	50 per cent tar with 16 per cent carbon.	[3]	7¾	827
Average			14.4				808
53	7.70 by 3.95 by 4	2.930	20.8	50 per cent creosote.	[2]	7½	790
28	8.20 by 3.60 by 4.2	2.980	8.8	50 per cent tar with 24 per cent carbon.	[4]	7¾	810
Average			14.8				800
51	7.70 by 3.10 by 4	2.345	20.7	50 per cent creosote.	[5]	7½	752
40	7.93 by 3.62 by 4	2.605	10.8	50 per cent tar with 30 per cent carbon.	[3]	7¾	827
Average			15.8				789

[1] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2 hours at 150 pounds.
[2] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2½ hours at 150 pounds.
[3] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2¾ hours at 150 pounds.
[4] Four and a half hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2½ hours at 150 pounds.
[5] Four hours at 80 pounds; 1 hour to obtain pressure up to 150 pounds; 2¼ hours at 150 pounds.

In all tests one-half hour was taken to obtain pressure up to 80 pounds.

TABLE 14.—*Data upon the relative absorptions and penetrations into longleaf pine of five different commercial creosotes.*

Specimen No.	Average number annual rings per inch.	Character of preservative.	Specific gravity at 60° C.	Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
				Pounds.	*Pounds.*	*Inches.*
V-1	19.0	Creosote No. 1 containing tar (estimated at about 10 per cent).	1.0483	3.493	0.072	3.58
A-D-8	8.0			4.517	.107	4.72
Average	13.5				.090	4.15
V-4	19.0	Creosote No. 2	1.0475	3.118	.152	6.58
A-D-2	6.0			3.801	.292	8.72
Average	12.5				.222	7.65
V-7	21.0	Pure coal-tar creosote No. 3	1.0576	3.120	.170	7.18
A-D-10	5.0			4.291	.249	8.66
Average	13.0				.210	7.92
V-5	20.0	Creosote containing tar No. 4 (estimated at less than 5 per cent).	1.071	3.010	.090	3.80
A-D-1	5.0			3.976	.224	7.60
Average	12.5				.157	5.70
V-8	21.0	High-boiling creosote No. 5	1.105	3.078	.076	3.73
A-D-3	5.0			4.828	.096	5.26
Average	13.0				.086	4.50

Average moisture in specimens about 6 per cent.

TABLE 15.—*Showing the effect on absorption and penetration when varying mixtures of tar No. 4 and creosote No. 6 are used.*

Specimen No.	Length.	Breadth.	Depth.	Weight before treatment.	Absorption.	Preservative used.	Pressure per square inch.	Time of treatment.
	Inches.	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*		*Pounds.*	*Hours.*
D-1	23.05	3.50	1.50	2.590	0.130			
E-4	24.20	3.55	1.55	2.780	.190	Creosote	80	2
F-5	23.15	3.50	1.50	2.610	.195			
Average					.172			
D-2	23.15	3.50	1.50	3.027	.070	80 per cent creosote		
E-2	24.20	3.50	1.50	2.698	.166	20 per cent tar	80	2
F-3	23.05	3.50	1.50	2.596	.138			
Average					.125			
D-3	14.40	3.50	1.50	1.923	.057	66⅔ per cent creosote		
E-6	24.20	3.50	1.50	2.920	.180	33⅓ per cent tar	80	2
F-2	23.05	3.50	1.50	2.607	.103			
Average					.113			

Specimen No.	Area penetrated.	Average longitudinal penetration.	Number of annual rings.	Depth of hole.	Preservative used.
	Sq. in.			*Inches.*	
D-1	10.8	4.9	14	1.00	
E-4	19.0	9.1	12	.99	Creosote.
F-5	13.1	6.0	14	1.00	
Average		6.7			
D-2	8.4	3.7	16	1.00	80 per cent creosote, 20 per cent tar.
E-2	15.1	7.0	12	1.00	
F-3	9.0	4.0	18	1.00	
Average		4.9			
D-3	7.5	3.2	17	1.00	66⅔ per cent creosote.
E-6	15.4	7.2	12	1.00	33⅓ per cent tar.
F-2	8.0	3.5	18	1.00	
Average		4.6			

It was not possible to get enough matched specimens from one stick for the three treatments. Three sticks were used and one specimen taken from each stick for each preservative.

Average moisture 8 per cent to 10 per cent.

TABLE 16.—*Showing the variation in: (1) Time of treatment, and (2) pressure necessary to secure a given absorption when varying mixtures of tar No. 4 and creosote No. 6 are used at a temperature of 160° F.*

Specimen No.	Length.	Breadth.	Depth.	Weight before treatment.	Absorption.	Preservative used.	Time of treatment.	Pressure.	Area penetrated.	Average longitudinal penetration.	Number of annual rings.	Depth of hole.
	Inches.	*Inches.*	*Inches.*		*Pounds.*		*Hours.*	*Lbs. per sq. in.*				
A-2	24.20	3.45	1.50	3.036	.074				17.7	8.35	10.0	1.00
B-1	24.20	3.40	1.50	3.210	.137	Creosote	2	80	21.4	10.20	15.0	1.00
C-6	20.30	3.48	1.50	2.287	.283				18.0	8.50	15.0	1.00
Average					.165					9.02		
A-5	24.20	3.45	1.40	2.860	.068		$4\frac{1}{4}$		14.0	6.37	10.0	1.02
B-2	24.20	3.45	1.45	2.995	.135	80 per cent creosote	5	80	15.5	7.25	15.0	1.00
C-7	20.35	3.45	1.50	2.210	.290	20 per cent tar	$2\frac{1}{12}$		18.5	8.75	15.0	1.00
Average					.164					7.46		
A-1	24.20	3.45	1.45	3.014	.046	$66\frac{2}{3}$ per cent creosote	[1] $6\frac{1}{2}$		8.0	3.75	10.0	1.00
B-3	24.15	3.45	1.45	2.920	.065		[2] 8	80	12.0	5.50	15.5	1.00
C-3	20.30	3.45	1.50	2.447	.288	$33\frac{1}{3}$ per cent tar	[3] $4\frac{1}{2}$		18.0	8.69	12.0	.98
Average					.133					5.98		
A-3	24.20	3.45	1.40	2.873	.057	80 per cent creosote		115	14.5	6.75	11.0	1.00
B-7	24.20	3.45	1.45	2.808	.092	20 per cent tar		155	10.0	4.50	19.0	1.00
C-4	20.35	3.50	1.45	2.300	.320		2	115	17.9	8.45	13.0	1.00
Average					.156					6.57		
A-6	24.20	3.45	1.45	2.825	.075	$66\frac{2}{3}$ per cent creosote		155	12.0	5.50	10.0	1.00
B-5	24.20	3.45	1.50	2.827	.083			155	12.3	5.65	10.0	1.00
C-2	20.25	3.45	1.50	2.440	.310	$33\frac{1}{3}$ per cent tar	2	150	17.0	8.00	16.0	1.00
Average					.156					6.38		

[1] The absorption given was obtained in about $5\frac{1}{2}$ hours' treatment.

[2] The absorption given was obtained in about $6\frac{1}{2}$ hours' treatment.

[3] The absorption given was obtained in about 4 hours' treatment.
The further increase in time of treatment did not increase the absorption.

NOTE 1.—It was necessary to use three different sticks to secure enough specimens for the tests. One specimen from each stick was used in each treatment. The three sticks in each treatment were, therefore, not matched with each other.

NOTE 2.—The average moisture content varied between 8 and 10 per cent.

TABLE 17.—*Summary of data contained in Table 16.*

Preservative.	Average time of treatment.	Average absorption.	Average pressure.	Average longitudinal penetration.	Absorption obtained.	Penetration obtained.	Increase in pressure.	Increase in time.
	Hours.	*Pounds.*	*Pounds per sq. in.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Creosote	2	0.165	80	9.02	100	100	0	[1] 0
80 per cent creosote; 20 per cent tar	4.05	.164	80	7.46	99	83	0	[1] 102
66⅔ per cent creosote; 33⅓ per cent tar	6.33	[2] .133	80	5.98	81	66	0	[1] 217
80 per cent creosote; 20 per cent tar	2	.156	128	6.57	95	73	60	[3] 0
66⅔ per cent creosote; 33⅓ per cent tar	2	.156	155	6.38	95	71	94	[3] 0

[1] Time varied.
[2] This absorption was obtained with an average of about 5½ hours' treatment. The further increase in the time of treatment failed to increase the absorption.
[3] Pressure varied.

See Note 1, Table 16.

TABLE 18.—*Data upon the relative absorptions and penetrations into longleaf pine of a mixture of equal parts of creosote No. 4 and a normal by-product coke-oven tar No. 1 at different temperatures (normal amount of free carbon in tar 6 per cent, by weight).*

Specimen No.	Average number annual rings per inch.	Temperature.	Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.
		°F.	*Pounds.*	*Pounds.*	*Inches.*
IX-6	12.0	160	2.570	0.046	2.98
VII-1	8.0	160	2.630	0.039	2.92
Average	10.0			0.042	2.95
IX-3	9.0	180	2.605	0.045	3.00
VII-3	11.0	180	2.635	0.075	4.23
Average	10.0			0.060	3.62
IX-1	11.0	190	2.728	0.038	3.18
VII-7	9.0	190	2.473	0.092	3.45
Average	10.0			0.065	3.32
IX-7	10.0	200	2.578	0.067	3.97
VII-4	8.0	200	2.615	0.103	4.76
Average	9.0			0.085	4.36
IX-2	10.0	210	2.480	0.094	4.76
VII-2	9.0	210	2.454	0.115	5.42
Average	9.5			0.104	5.09

Average moisture in specimens about 10 per cent.

TABLE 19.—*Data on absorption tests on paving blocks with tar and creosote mixtures.*

Block No.	Dimensions.	Volume.	Weight before treatment.	Weight 24 hours after treatment.	Absorption.	Preservative.	Time of treatment.	Temperature.	Pressure.	Viscosity at treating temperature.
	Inches.	*Cubic feet.*	*Pounds.*	*Pounds.*	*Pounds per cubic foot.*		*Minutes.*		*Pounds per square inch.*	
1	8.05 by 4.2 by 4.15	0.081	3.88	5.03	14.2					
2	8.10 by 4.2 by 4.2	0.083	4.03	5.43	16.9					
3	8.10 by 4.25 by 4.15	0.083	3.85	5.10	15.1	Creosote (specific gravity at 60° C. 1.071)	40	180	100	1.15
4	8.10 by 4.2 by 4.15	0.082	3.93	5.10	14.3					
Average					15.1					
9	8.1 by 4.3 by 4.1	0.083	3.67	4.97	15.7					
10	8.1 by 4.25 by 4.1	0.082	3.82	5.05	15.0					
11	8.0 by 4.2 by 4.15	0.081	3.78	5.13	16.7	Creosote	25	220	200	1.10
12	8.1 by 4.25 by 4.05	0.081	3.66	4.92	15.6					
Average					15.8					
13	8.0 by 4.2 by 4.2	0.082	3.79	5.04	15.2					
14	8.1 by 4.05 by 4.2	0.080	3.62	4.84	15.3					
15	8.1 by 4.2 by 4.15	0.082	3.76	4.94	14.4	Creosote	120	160	75	1.20
16	8.1 by 4.2 by 4.3	0.085	4.10	5.50	16.5					
Average					15.4					
25	8.05 by 4.15 by 4.25	0.082	4.05	5.66	19.7	75 per cent creosote				
26	8.1 by 4.05 by 4.2	0.080	3.60	4.94	16.7	25 per cent tar				
27	8.1 by 4.2 by 4.1	0.081	3.73	5.10	16.9	Mixture (specific gravity at 60° C. 1.086)	30	220	200	1.33
28	8.1 by 4.15 by 4.1	0.080	3.69	4.98	16.1					
Average					17.3					
29	8.0 by 4.15 by 4.15	0.080	3.71	4.98	15.9	50 per cent creosote				
30	8.0 by 4.1 by 4.25	0.081	4.04	5.48	17.8	50 per cent tar				
31	8.1 by 4.1 by 4.2	0.081	3.65	4.77	13.8	Mixture (specific gravity at 60° C. 1.109)	40	220	200	1.42
32	8.1 by 4.15 by 4.25	0.083	4.05	5.30	15.1					
Average					15.6					
37	8.1 by 4.25 by 4.2	0.084	4.00	5.24	14.8	25 per cent creosote				
38	8.1 by 4.1 by 4.25	0.082	3.65	5.00	16.5	75 per cent tar				
39	8.1 by 4.2 by 4.25	0.084	4.05	5.41	16.2	Mixture (specific gravity at 60° C. 1.149)	75	220	200	1.60
40	8.1 by 4.15 by 4.1	0.080	3.59	4.96	17.1					
Average					16.2					

TABLE 20.—*Penetrance tests on longleaf pine with mixtures of tar No. 5 and creosote No. 4.*

Specimen No.	Average number annual rings per inch.	Moisture per cent, (average).	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed	Average longitudinal penetration.	Time of treatment.	Temperature.	Pressure.
			Tar No. 5.	Creosote.	Free carbon in mixture.	Specific gravity at 140° F. (60° C.)	Viscosity at treating temperature.						
			Per cent by volume.	*Per cent by volume.*	*Per cent by weight.*			*Pounds.*	*Pounds.*	*Inches.*	*Minutes.*	° *F.*	*Pounds per square inch.*
1-1	19	9.3	.....	100	.....	1.071	1.15	3.950	0.036	2.83	40	180	100
2-1	9							3.475	0.005	1.23	40	180	100
3-1	13							3.222	0.018	1.30	40	180	100
4-1	9							3.105	0.019	1.50	40	180	100
									0.0195	1.72			
1-5	19	2.2	.....	100	.....	1.071	1.10	3.380	0.190	6.83	25	220	200
2-5	9							3.115	0.085	3.50	25	220	200
3-5	11							3.094	0.041	2.37	25	220	200
4-5	9							3.100	0.100	3.17	25	220	200
									0.104	3.97			
1-7	18	9.5	.....	100	.....	1.071	1.2	3.586	0.107	6.50	120	160	75
2-7	10							3.000	0.015	2.50	120	160	75
3-7	8							3.223	0.017	2.03	120	160	75
4-7	11							3.087	0.013	2.17	120	160	75
									0.038	3.30			
1-2	18	5.6	25	75	3.6	1.086	1.33	3.516	0.164	6.00	30	220	200
2-2	9							3.366	0.042	2.50	30	220	200
3-2	10							3.236	0.064	3.50	30	220	200
4-2	10							3.045	0.059	2.37	30	220	200
									0.082	3.59			
1-3	18	10.2	50	50	7.1	1.109	1.42	3.568	0.102	3.83	40	220	200
2-3	10							3.066	0.054	2.50	40	220	200
3-3	11							3.320	0.044	3.83	40	220	200
4-3	11							2.918	0.052	2.50	40	220	200
									0.063	3.16			
1-4	17	5.3	75	25	10.9	1.149	1.60	3.550	0.085	4.17	75	220	200
2-4	12							2.970	0.060	2.17	75	220	200
3-4	10							3.100	0.080	2.50	75	220	200
4-4	10							3.090	0.074	2.88	75	220	200
	11.7								0.075	2.92			

TABLE 21.—*Data upon the relative penetration and absorption into longleaf pine of a mixture of 25 per cent creosote No. 4 and 75 per cent tar No. 5 at different treating tempertures (normal amount of free carbon in the tar 14 per cent by weight).*

Specimen No.	Average number annual rings per inch.	Moisture.	Character of preservative.					Weight of specimen directly before treatment.	Preservative absorbed.	Average longitudinal penetration.	Time of treatment.	Temperature.	Pressure.
			Tar No. 5.	Creosote.	Free carbon in mixture.	Specific gravity at 140° F.) (60° C.	Viscosity at treating temperature.						
		Per cent.	*Per cent by volume.*	*Per cent by volume.*	*Per cent by weight.*			*Pounds.*	*Pounds.*	*Inches.*	*Minutes.*	*° F.*	*Pounds per square inch.*
5-1	18	2.0	75	25	10.9	1.149	1.60	3.910	0.066	2.83	60	220	200
6-1	10							3.125	0.080	3.17	60	220	200
7-1	18							3.895	0.045	2.17	60	220	200
									0.064	2.72			
5-3	19	6.0	75	25	10.9	1.149	2.50	3.888	0.062	3.50	60	190	200
6-3	10							3.290	0.032	2.17	60	190	200
7-3	17							4.370	0.050	1.67	60	190	200
									0.048	2.45			
5-2	20	6.4	75	25	10.9	1.149	5.00	4.243	0.017	1.17	60	160	200
6-2	13							3.280	0.035	1.70	60	160	200
7-2	16							3.905	0.025	1.50	60	160	200
									0.026	1.46			

TABLE A.—*Showing composition of treating oil.*

(See penetrance specimens on Pl. IV.)

Piece No.	Creosote No. 4, per cent of total oil by volume.	Tar No. 3, per cent of total oil by volume.	Free carbon, per cent of total oil by weight.
1	0	100	Trace.
2	25	75	Trace.
3	50	50	Trace.
4	75	25	Trace.
5	100	0	Trace.

TABLE B.—*Showing composition of treating oil.*

(See penetrance specimens on Pl. V.)

Piece No.	Creosote No. 4, per cent of total oil by volume.	Tar.		Free carbon, per cent of total oil by weight.	Tar No.
		Per cent of total oil by volume.	Amount of carbon normal to the tar, per cent of total weight of tar.		
1	50	50	6	Trace.	1
2	50	50	16	Trace.	2
3	50	50	30	Trace.	3
4	50	50	6	3	1
5	50	50	16	8	2
6	50	50	30	15	3

TABLE C.—*Showing composition of treating oil.*

(See penetrance specimens on Pl. VI.)

Piece No.	Creosote No. 4, per cent of total oil by volume.	Tar No. 2, per cent of total oil by volume.	Carbon per cent by weight.
1	50	50	Trace.
2	50	50	3
3	50	50	5
4	50	50	6.5
5	50	50	8

TABLE D.—*Treating oil.*

(See penetrance specimens on Pl. VII.)

Piece No.	Creosote No.	Treating oil.
1	1	Creosote containing tar (estimated at about 10 per cent).
2	2	Creosote.
3	3	Pure coal-tar creosote.
4	4	Creosote containing tar (estimated at less than 5 per cent).
5	5	High-boiling creosote.

TABLE E.—*Showing temperature of treatment.*

(See penetrance specimens on Pl. XI.

Piece No.	Temperature of treatment.
1	160
2	180
3	190
4	200
5	210

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 608

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. ▼ March 6, 1918

VARIETIES OF CHEESE: DESCRIPTIONS AND ANALYSES.[1]

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INTRODUCTION.

In the fiscal year 1901 the importations of cheese into the United States were valued at $1,946,033, and since then have increased very greatly, as shown in the table below:

TABLE I.—*Importations of cheese into the United States.*

1901	$1,946,033
1905	3,875,161
1910	7,053,570
1911	7,920,244
1912	8,807,249
1913	9,185,184
1914	11,010,693

A number of varieties are included in these importations, and nearly all are among the highest priced cheeses made, such as Emmental from Switzerland, Parmesan and Gorgonzola from Italy, Roquefort, Camembert, and Brie from France, and Edam from Holland.

[1] This bulletin is a revision of Bureau of Animal Industry Bulletin 146, which was issued in 1911, and which in turn was a revision of Bureau of Animal Industry Bulletin 105, issued in 1908. Dr. Lawson was a joint author of the original work, but is not responsible for the changes embodied in the present edition. Acknowledgment is made of suggestions and information received from the Bureau of Chemistry.

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The attempt to make Emmental and Limburg cheese in this country has been very successful, as is proved by the statement that in Wisconsin alone 500 factories are making these varieties; also, some factories in Ohio, New York, and northern Illinois are making them. Investigation by this department in cooperation with the experiment station at Storrs, Conn., has demonstrated that Camembert, and also a cheese of the same general nature as Roquefort or Stilton, can be made successfully in this country. There is no reason to believe that any variety of cheese imported can not be made here, although with present knowledge it would not be advisable to try to make many kinds. Probably scientific investigation would show how to improve on the average quality of the cheese made in the old countries, for it must be remembered that only the very best is shipped by the European makers, the rest, or poorer grades, being consumed at home. Unfortunately, a feeling is prevalent in the United States that cheese equal to the best of the European product can not be produced here. This feeling is based upon a lack of knowledge of actual conditions in Europe and of the conditions affecting the qualities of cheese. Certain parts of Europe probably are better favored by desirable climatic conditions and by more general dissemination of the bacteria or molds necessary to the characteristic ripening of different varieties, but even the best average natural conditions can be improved on by artificial means, since necessary molds or bacteria can be grown in pure cultures and utilized anywhere. However, the cost may render it impracticable.

It is an unfortunate fact that the sale of homemade varieties of European cheese is seriously handicapped by the partiality of consumers for foreign labels. The prejudice against American-made cheese has been intensified to a great degree by the practice of dealers who sell the better grades of homemade cheese as imported, and the poorer grades as domestic. It is probable that this practice continues in the sale of domestic Swiss or Emmental, as there is at present no means of detecting fraud in the sale of that type of cheese.

The demand for information concerning the different varieties of cheese has become general, and the information is not very accessible to those unable to read other languages than English. The apparent need of some work of reference in connection with both the importation and the home production of cheese has therefore led to the prepartion of the descriptive notes and the compilation of the analytical data in this bulletin.

The descriptions are for the most part based upon data found in treatises on dairying and in articles in foreign periodicals. While in many instances they are very incomplete and possibly in some cases inaccurate, they nevertheless contain in condensed form practically all the important information that it has been possible to obtain

in an extended search through the literature relating in any way to the subject. Owing to the large number of publications consulted, it has seemed impracticable to give references to the descriptive matter.

As will be noted, names and descriptions have been arranged alphabetically, and no attempt has been made to classify the varieties. All such attempts made by others have been unsatisfactory and are open to serious criticism. There are probably about 18 distinct varieties of cheese. All the rest, consisting of more than 400 names given, are of local origin, usually named after towns or communities. A list of the best known names applied to each of these distinct varieties or groups is given: Brick, Caciocavallo, Camembert, Cheddar, Cottage, Dry, Edam, Emmental, Gouda, Hand, Holstein, Limburg, Neufchâtel, Parmesan, Roquefort, Sapsago, Scanno, and Trappist.

As stated, many of the names in the body of the bulletin are duplicates. It is the practice in most European countries to give local names to cheese; it is said that in France more than 250 names are applied to cheese, while in fact probably not more than a dozen distinct kinds of cheese are made there. This naturally leads to much confusion, and especially is it true, as often happens, when a local name is given to more than one variety. It would certainly appear to be more rational to retain or employ variety names and give the names of the localities where manufactured. It is possible for a local name to mean much, but when it is used alone to apply to a number of varieties of the same product it means nothing.

In most instances in this bulletin the analyses have been compiled from the original publications. In all cases, however, the sources of the data have been given in the list of references which follows the table of analyses. No effort has been made to collect the numerous analyses of filled cheese, and in the case of American Cheddar cheese only a part of the available data has been included in the compilation.

DESCRIPTION OF VARIETIES OF CHEESE.

ABERTAM.

This is a hard, rennet cheese made from sheep's milk in the region of Carlsbad, Bohemia.

ALEMTEJO.

This name is applied to rather soft cheeses made in the Province of Alemtejo, Portugal. They are cylindrical in shape and are made in three sizes, averaging about 2 ounces, 1 pound, and 4 pounds, respectively. They are made for the most part from the milk of sheep, though goats' milk is often added, especially for the smaller sizes. The milk is warmed and curdled usually with an extract prepared from the flowers of a kind of thistle. The cheeses are ripened for several weeks.

ALPIN.

This is a kind of Mont d'Or cheese made in the Alpine regions of France. It is also known as Clérimbert. The milk is coagulated with rennet at 80° F. in two hours. The curd is dipped into molds 3 or 4 inches in diameter and 2½ inches in height. The cheese is allowed to drain and is turned several times during one day, after which it is salted and ripened for from 8 to 15 days.

ALTENBURG.

This is a goats'-milk cheese made in Germany, where it is known as Altenburger Ziegenkäse. A cheese is 8 inches in diameter, 1 or 2 inches in thickness, and weighs about 2 pounds.

AMBERT.

This cheese, known as Fourme d'Ambert, is a cylinder-shaped imitation Roquefort cheese made from cows' milk. It is said to differ from other forms of blue or imitation Roquefort cheese made in the southeastern part of France in that the salt is mixed with the curd rather than rubbed on the surface of the cheese.

ANCIEN IMPÉRIAL.

In this cheese the curd is prepared in the same manner as for Neufchâtel. It is also known as Petit Carré and, when ripened, as Carré Affiné. The cheese is about 2 inches square and one-half inch thick, and is sold and consumed both while fresh and after ripening. The ripening process is not essentially different from that of Neufchâtel.

APPENZELL.

This cheese, which is very similar to Emmental, is made of cows' milk in the Canton of Appenzell, Switzerland, and also in Bavaria and Baden. It is usually made of skim milk, but sometimes of whole milk.

ARMAVIR.

Armavir cheese is made in the western Caucasus from the whole milk of sheep. It is made of sour milk, resembles hand cheese, and is produced by pouring sour buttermilk or whey into the heated milk. The cheese is pressed into forms and allowed to ripen in a warm place.

BACKSTEIN.

Backstein, meaning brick, is so called from its shape, but it is not identical with the Brick cheese made in the United States. The process of manufacture is similar to that of Limburg.

BANBURY.

This was a soft, rich cheese, very popular in England in the early part of the nineteenth century. It was a cylindrical cheese about 1 inch thick.

BARBEREY.

This is a soft, rennet cheese resembling Camembert and deriving its name from the village of Barberey, near Troyes, France. It is also commonly known as Fromage de Troyes. The milk while still fresh and warm is coagulated with rennet, the time allowed being usually about four hours. The uncut curd is put into a wooden mold having a perforated bottom. After draining

for three hours the cheese is turned into an earthenware mold, the wooden one being removed after 24 hours. The cheeses are salted, dried in a well-ventilated room, and ripened for about three weeks, usually in a subterranean curing room. In summer the cheese is often sold without ripening. A cheese is 5 or 6 inches in diameter and 1¼ inches in thickness.

BATTLEMAT.

This is an Emmental cheese made in the Canton of Tessin, Switzerland, in the western part of Austria, and in the northern part of Italy. It is recommended for localities where a great quantity of milk can not be obtained. The cheese is circular in form, about 16 inches in diameter and 4 inches high, and weighs from 40 to 80 pounds. It is cooked at a slightly lower temperature than the Emmental and is a little softer when ripened. It ripens more rapidly than the Emmental, being ready for market in about four months.

BAUDEN.

Baudenkäse is a sour-milk cheese made in the herders' huts in the mountains between Bohemia and Silesia in essentially the same manner as Harzkäse. It is made up in two forms, one conical with a diameter and a height of 3½ inches, and the other cylindrical, with a diameter of 5 inches and a height of 2½ inches. It is also known locally as Koppenkäse.

BELGIAN COOKED.

The milk, which has been allowed to curdle spontaneously, is skimmed and the curd heated to 135° or 140° F. and then placed in a cloth and allowed to drain. When dry it is thoroughly kneaded by hand and is allowed to undergo fermentation, which takes ordinarily from 10 to 14 days in winter and six to eight days in summer. When the fermentation is complete, cream and salt are added and the mixture is heated gently and stirred until homogeneous, when it is put into molds and allowed to ripen for eight days longer. A cheese ordinarily weighs about 3½ pounds. It is not essentially different from other forms of cooked cheese.

BELLELAY.

This is a soft, rennet cheese made from whole milk and sometimes called Tête de Moine, or Monk's Head. This cheese originated with the monks of the Canton of Bern, Switzerland, in the fifteenth century, and at the present time is made exclusively in that locality.

The sweet milk is set at about 90° F. with sufficient rennet to coagulate it in 20 or 30 minutes. The curd is cut comparatively fine and is stirred while being heated slowly to a temperature of 110° F. It is cooked much firmer than Limburg and not so firm as Emmental.

When cooked the curd is dipped into wooden hoops lined with cloth. The cheeses are pressed in rotation for a few minutes at a time, one press being used for a number of cheeses. After pressing, the cheeses are wrapped in bark for two weeks, or until they are firm enough to require no support. They are cured in a moist cellar at a comparatively low temperature, as it is not desired to have eyes develop. The cheese when ready for market has a diameter of 7 inches and weighs from 9 to 15 pounds. It ripens in about 12 months and will keep for three or four years. It has a soft, buttery consistency and can be spread on bread for eating.

BERGQUARA.

This is a Swedish cheese resembling Gouda. It was known in Sweden in the eighteenth century.

BGUG-PANIR.

This cheese, sometimes called Daralag, is made in Armenia from sheep's milk, partially or entirely skimmed. Rennet is used for coagulation and the curd is put into a rack for draining, after which it is broken up and salt and herbs added. After pressing again, the cheese is put into a salt bath, usually for two days, but sometimes for two months.

BITTO.

This is a cheese of the Emmental group, made in northern Italy. It is sometimes eaten fresh and sometimes ripened for two years, when it is very hard and has small eyes.

BLEU.

The names Pâté Bleu and Fromage Bleu are applied to several kinds of hard, rennet cheese made from cows' milk in imitation of Roquefort cheese in the southeastern part of France. Owing to the mottled, marbled, or veined appearance they are also designated Fromage Persillé. Among these are Gex, Sassenage, and Septmoncel. This name is also applied locally to several more or less distinct kinds made in the regions of the Auvergne and Aubrac Mountains and designated Bleu d'Auvergne, Cantal, Guiole or Laguiole, and St. Flour. Other cheeses of this order mentioned as made in France are Queyras, Champoléon, Sarraz, and Journiac.

BOUDANNE.

This is a French cheese made from cows' milk. The milk, either whole or skimmed, is heated to about 85° F., sufficient rennet is added to coagulate it in one hour, and the curd is cut to the size of peas, stirred, and heated to 100° F. or above. After standing for 10 or 15 minutes the curd is pressed by hand and put into molds 8 inches in diameter and 3 inches in height. The cheeses are drained, turned frequently, salted, and ripened for two or three months.

BOX (FIRM).

This cheese, known in different localities where made as Hohenburg, Mondsee, and Weihenstephan, is made from cows' milk, whole, and is a rather firm rennet cheese. The flavor is said to be mild but piquant. The milk is heated to 90° or 93° F. in a kettle, colored with saffron, and set with sufficient rennet to curdle it in 20 or 25 minutes. The curd is cut up as fine as peas, and the contents of the kettle are heated very slowly to a temperature of 105° F., being stirred meanwhile. The fire is then removed and the curd allowed to settle for five minutes, when the whey is dipped off. The curd is then dipped into a cloth, whence it is scooped into hoops. Light pressure is applied, in 15 minutes the cheese is turned, and the turning is repeated frequently for several hours. The cheese is kept in a well-ventilated room at 60° F. for from three to five days, after which it is taken to the cellar. It is salted by rubbing or sprinkling salt on the surface. Ripening requires from two to three months. The cheese weighs from 1 to 4 pounds, and is undoubtedly similar to the Brick cheese of the United States.

BOX (SOFT).

This is a rennet cheese made from cows' milk, partially skimmed, and known locally as Schachtelkäse. It is a rather unimportant variety produced in Württemberg in a small locality called Hohenheim, a name which the cheese often takes.

In making this cheese the evening's milk, skimmed, is mixed with the whole milk drawn that morning, or a part of the milk is skimmed with a centrifuge and is mixed with an equal volume of whole milk. The cheese is made in a copper kettle. The milk is warmed to 110° F., colored with saffron, and rennet added. It is allowed to stand for one or one and one-half hours before cutting. The curd is cut into rather coarse particles, after which it is allowed to stand for a few minutes, when the whey is dipped off, and for every 200 pounds of milk used a small handful of caraway seed is added. The curd is then dipped into hoops 6½ inches in height and the same in diameter. It remains in these hoops for 10 hours and is frequently turned, after which it is transferred to a wooden hoop only one-half as high, where it remains for 12 hours. The cheese is then sprinkled with salt and put into the ripening cellar, where it remains about three months.

A soft, rennet cheese known as Fromage de Boîte is made in the fall in the mountains of Doubs, France, and resembles Pont l'Évêque.

BRA.

This cheese is made by nomads in the region of Bra in Piedmont, Italy. It is a hard, rennet cheese weighing about 12 pounds. The milk, which is partly skimmed, is heated to about 90° F., and sufficient rennet is added to coagulate it in 30 or 40 minutes. The curd is cut to the size of rice grains and the whey removed after about half an hour. It is then put into a form about 12 inches in diameter and 3 inches in height and subjected to pressure for from 12 to 24 hours. The cheese is salted by immersion in brine and also by sprinkling salt on the surface, after which it is ripened.

BRAND.

This is a German hand cheese weighing about one-third of a pound, made from sour-milk curd cooked at a little higher temperature than ordinarily practiced. The curd is salted and allowed to ferment one day. It is then mixed with butter, pressed into shape and dried, and finally placed in kegs to ripen, during which process it is moistened occasionally with beer.

BRICK.

The exact derivation of this name is not known. It may have been adopted because of the shape, or because of the fact that bricks are used almost exclusively for weighting down the press. Brick cheese is a rennet cheese made from cows' milk, unskimmed, and is purely an American product. In characteristics it is about halfway between Limburg and Emmental. It has a strong, sweetish taste, a sort of elastic texture, and many small, round eyes or holes. It is made about 10 by 6 by 3 inches in size. Many factories, especially in southern Wisconsin, make this product.

Perfectly sweet milk is set in a vat at 86° F. with sufficient rennet to coagulate it in 20 or 30 minutes. The curd is cut with Cheddar curd knives, is then heated to 110° or 120° F., and is stirred constantly. The cooking is continued until the curd has become so firm that a handful squeezed together will

fall apart when released. The curd is then dipped into the mold, which is a heavy rectangular box without a bottom and with slits sawed in the sides to allow drainage. The mold is set on the draining table, a follower is put on the curd, and one or two bricks are used on each cheese for pressure. The cheeses are allowed to remain in the molds for 24 hours, when they are removed, rubbed all over with salt, and piled three deep. The salting is done each day for three days, after which the cheese is taken to the ripening cellar, which should be comparatively moist and have a temperature of from 60° to 65° F. Ripening requires two months.

BRICKBAT.

This is a rennet cheese made as early as the eighteenth century in Wiltshire, England. It is made from fresh milk to which a small portion of cream has been added. The milk is set at about 90° F. and allowed to stand two hours before the curd is disturbed. The curd is cut coarse, dipped into wooden forms, and light pressure applied. The cheese is said to be fit for consumption for one year after being made.

BRIE.

This is a soft, rennet cheese made from cows' milk, varying in size and also in quality, depending on whether whole or partly skimmed milk is used. The method of manufacture resembles closely that of Camembert.

This cheese has been made in France for several centuries, having been mentioned as long ago as 1407. It is made throughout France, but more extensively in the Department of Seine et Marne, in which it doubtless originated. This department contains Meaux, Coulommiers, and Melun, places noted for their manufacture of Brie cheese, though often under local names. More or less successful imitations of this cheese are made in other countries. It was estimated that 7,000,000 pounds of Brie cheese was sold in Paris during 1900. The export trade is also very important.

The milk used is usually perfectly fresh. It is not uncommon, however, to mix the evening's milk, when kept cool overnight, with the morning's milk. Some artificial coloring matter is added to the milk, which is then set with rennet at a temperature of 80° or 85° F. After standing undisturbed for about two hours, the curd is dipped into forms or hoops, of which there are three sizes in common use. The largest size is about 15 inches in diameter, the medium size about 12 inches in diameter, and the smallest size about 6 inches in diameter, all varying in height from 2 to 3 inches. After drainage for 24 hours without pressure being applied, the hoops are removed, and the surface of the cheese is sprinkled with salt. Charcoal is sometimes mixed with the salt used. The cheese is then transferred to the first curing room, which is kept dry and well ventilated. After remaining in this room for about eight days the cheese becomes covered with mold. It is then transferred to the second curing room or cellar, which is usually very dark, imperfectly ventilated, and has a temperature of about 60° F. The cheese remains there for from two to four weeks, or until the consistency and odor indicate that it is sufficiently ripened. The red coloration which the surface of the cheese finally acquires has been attributed to an organism designated *Bacillus firmaticus*. The ripening is due to one or more species of molds which occur on the surface and produce enzyms, which in turn cause a gradual and progressive breaking down of the casein from the exterior toward the center. The interior of a ripened cheese varies in consistency from waxy to semiliquid and has a very pronounced odor and a sharp, characteristic taste.

BRINSEN OR BRINZA.

This cheese, known locally as Landoch, Zips, Liptau, Siebenbürgen, Neusohl, Altsohl, and Klencz, is made in the Carpathian Mountains of Hungary from sheep's milk, or a mixture of sheep's and goats' milk.

The cheese is made in small lots, from 2 to 4 gallons of milk being used at one time. This is put into a kettle when fresh, and sufficient rennet is added with the milk at a temperature of from 75° to 85° F. to secure coagulation in 15 minutes. The curd is broken up and the whey dipped, and the curd is placed in a linen sack and allowed to drain for 24 hours. It is then cut into pieces and placed on a board, where with frequent turnings it is allowed to remain until it commences to get smeary, which requires about eight days. The pieces are then laid one on top of another in a vessel holding from 40 to 60 pounds, where they remain for 24 hours, after which they are removed, the rind cut away, and the curd or partially cured cheese broken up in another vessel. After 10 hours salt is stirred in and the curd run through a mill, which cuts it very fine, when it is packed in a tub with beech shavings.

BROCCIO.

This is a sour-milk cheese made from sheep's milk in Corsica. It is sometimes mixed with sugar and rum and made into small cakes. It is similar to Ziger.

BURGUNDY.

This cheese, known in France as Fromage de Bourgogne, is described as a soft, white, loaf-shaped cheese weighing about 4 pounds.

BUTTERMILK.

This cheese, made from the curd of buttermilk, is of somewhat finer grain than skimmed-milk cottage cheese, which it closely resembles. Buttermilk of 0.5 or 0.6 per cent acidity is run into a steam-heated vat or starter can, or placed in a pail which can be heated in a tub of hot water. The buttermilk is stirred and heated to 75° or 78° F., then covered and left for one and one-half or two hours. The temperature is then raised to 140° F., and in about one hour the curd settles to the bottom. The whey is removed and the curd transferred to a draining cloth or bag for about 10 hours. It should be stirred occasionally while draining. When dry the curd is salted, put up in small packages, and wrapped in parchment paper.

CACIOCAVALLO.

This is a somewhat peculiar kind of cheese made from either whole or partly skimmed milk of cows. Various explanations have been made as to the origin of the name, which means literally horse cheese. One explanation offered is that the cheese was originally made in the region of Monte Cavallo, and another is that the imprint of a horse's head was made in each cheese as the trade-mark of the original manufacturer. The original home of this cheese was southern Italy, but it is now made extensively in northern Italy as well. The history of the cheese dates back several centuries.

The temperature of the coagulation of the milk with rennet varies greatly but is usually from 90° to 95° F. The time allowed for coagulation is also variable, being usually about one-half hour. The curd is cut very fine and sometimes allowed to ferment for 24 hours, when it is heated by means of very hot water, or more commonly hot whey, and subsequently worked by hand until all the whey is expressed and the curd becomes homogeneous and capable

of being drawn out into long threads. It is then molded into any desired shape and salted by immersion in brine for about two days. The cheeses are suspended in pairs from the ceiling and lightly smoked. The surface may be rubbed with olive oil or butter. They are kept in a cool, dry room until sold. As seen on the market they vary much in size and shape, and weigh about 3 pounds. The most common shape is that resembling a beet, a constriction near the top being due to the string which is tied around the cheese for the purpose of hanging it up. This cheese is sometimes eaten while comparatively fresh, but is more frequently kept for months, then grated and used for flavoring soups and as an addition to macaroni and similar foods. A small quantity is imported into the United States.

CACIO FIORE.

This is a soft, rennet cheese made in Italy from sheep's milk. Throughout the process comparatively low temperatures are maintained. The soft curd is put into square forms capable of holding about 4 pounds of cheese. The cheese has a consistency like butter, has a sweetish taste, and is eaten fresh.

CAERPHILLY.

This is a hard, rennet cheese made in Wales from cows' milk, unskimmed. The milk is set very sweet at a temperature of 85° F. with rennet enough to coagulate it in one hour. The curd is cut in $\frac{1}{3}$-inch cubes and stirred for one hour without further heating. It is then put into cloths and subjected to light pressure for an hour and is again broken up fine and put to press, where it remains, with daily changing, for three days. During this time one-half ounce salt to each pound of curd is rubbed on the surface. Each cheese weighs about 8 pounds and requires about three weeks for ripening, at a temperature of 65° or 70° F.

CAMBRIDGE.

This is a soft, rennet English cheese made from cows' milk set at 90° F. and rennet added. At the end of one hour the curd is dipped into molds without cutting and allowed to stand for 30 hours, when it is ready for eating.

CAMEMBERT.

This is a soft, rennet cheese made from cows' milk. A typical cheese is about $4\frac{1}{4}$ inches in diameter, three-quarters of an inch or 1 inch thick, and in the market in this country is usually found wrapped in paper and inclosed in a wooden box of the same shape. The cheese usually has a rind about one-eighth of an inch in thickness, which is composed of molds and dried cheese. The interior is yellowish in color and waxy, creamy, or almost fluid in consistency, depending largely upon the degree of ripeness.

Camembert cheese is said to have originated in 1791 in the locality from which it derives its name in the Department of Orne, in the northwestern part of France. The industry extended soon into Calvados, and these two departments are still the principal seat of the industry. Cheese of the same type, however, is made in other parts of France and also in other countries; among them are Compiègne, Contentin, Pavillon, Soumaintrain, and Thury-en-Valois. Very successful results have been obtained at the Storrs Agricultural Experiment Station in Connecticut.

Camembert cheese is made from whole milk or from milk slightly skimmed. It is not advisable to skim the milk unless it tests more than 3.5 per cent fat. The temperature of setting is from 78° to 87° F., and the quantity of rennet added

for this purpose is sufficient to get the desired degree of firmness in from two to five hours. The curd is then transferred, usually with as little breaking up as possible, to perforated tin forms or hoops about 4¼ inches in diameter and the same in height. These rest upon rush mats, which permit free drainage. The filling of the forms may be done at two or three times, separated by short intervals allowed for the curd to settle. Each form holds the equivalent in curd of about 2 quarts of milk. After draining for about 18 hours, preferably in a room having a uniform temperature of 65° or 70° F., the cheese is turned. This is repeated frequently for about two days, when it is removed from the forms and salted on the outside. After 24 hours the cheese is carried to the curing rooms, which are maintained at temperatures of from 53° to 59° F. and with a high relative humidity. Curing the cheese is the most difficult part of the manufacturing process, for not only must there be a uniform and progressive development of the ripening agents, but the curd must be gradually desiccated at the same time. Proper conditions of humidity and temperature must be maintained and subject to regulation in order to favor the development of the needful mold, *Penicillium camemberti*, the bacteria, and yeasts. While the growth of the mold is necessary in order to bring about a gradual breaking down of the casein, this growth should not be too vigorous and luxuriant; otherwise the product will be rendered unfit for commercial purposes. Following the growth of the mold, other organisms develop, giving the resultant cheese a reddish appearance instead of a white and blue, as is the case in the initial mold fermentation. From 15 to 20 days are required to bring about the proper balance between the various forms of life. At the end of that time the cheese is allowed to complete its ripening at the lower limits of the indicated temperatures and with a minimum of ventilation. From four to six weeks are normally required before this variety of cheese is in fit condition for the market.

CANQUILLOTE.

This is a skim-milk cheese made in the eastern part of France. It is also known locally as Fromagère and Tempête. The milk is allowed to coagulate spontaneously, after which it is heated gently and the whey drawn off. The curd is pressed in order to remove as much of the whey as possible, crumbled fine, and fermented at a temperature of about 70° F. for two or three days, during which time it is stirred frequently. When the cheese has acquired its characteristic taste it is melted with the addition of water, salt, eggs, and butter and put into molds of various kinds.

CANTAL.

This is a hard, rennet cheese made from cows' milk more or less skimmed. Its manufacture is extensive in the Department of Cantal, France. It is also known as Auvergne or Auvergne Bleu on account of its being manufactured in the region of the Auvergne Mountains. Locally the cheese is commonly known as Fourme. The cheese is doubtless a very old variety, and the method of manufacture has remained quite primitive. The milk, usually fresh but sometimes several hours old, is set with rennet at a temperature of about 85° F., the time allowed for coagulation being about 30 minutes. The curd is then cut very fine and the whey dipped off. The curd is subjected to pressure in order to remove as much of the whey as possible, and is allowed to ferment for 24 hours, which process is considered very important. The curd is then broken up by hand or by machinery and salted at the rate of 2.5 or 3 per cent. When thoroughly kneaded it is put into hoops about 14 inches in diameter. Pressure

is applied for about two days, during which time it is turned very frequently. The cheese is next transferred to the curing cellar, where it remains for from six weeks to six months. The yield of cheese is usually 10 or 11 per cent of the weight of the milk. A ripened cheese weighs from 40 to 120 pounds.

CHAMPOLÉON.

Champoléon, or Queyras, is a hard, rennet cheese made from skim milk in the Department of Hautes-Alpes, France.

CHAOURCE.

This is a soft, whole-milk rennet cheese resembling Camembert and deriving its name from the village of Chaource, in the Department of Aube, France. It is about 4 inches in diameter and 3 inches thick.

CHASCHÔL DE CHASCHOSIS.

This cheese is made in the Canton of Grisons, Switzerland. It is a hard rennet cheese made from cows' milk, skimmed. The cheeses are from 18 to 22 inches in diameter, 3 to 4 inches high, and weighs from 22 to 40 pounds.

CHEDDAR.

This cheese is so named from the village of Cheddar in Somersetshire, England, where it was first made. It is comparatively an old cheese, though the genuine Cheddar process as it is now known is not old. It is an exceedingly popular variety, being much used as a food product in America and England, and is probably the most important of all cheeses as regards the quantity made annually. As used at the present time, the term Cheddar applies usually to a process of making rather than to any particular shape of cheese. The name, however, is occasionally used to designate a certain size of cheese 14 or 16 inches in diameter, and weighing from 60 to 100 pounds. Cheese made by the Cheddar process has, however, many different shapes with distinguishing names, such as Flats, which have the same diameter as the Cheddar size, but weigh only 30 or 40 pounds; Daisies, which are 12 inches in diameter and weigh 20 pounds; Young Americas, which are 8 inches in diameter and weigh 8 to 12 pounds; Long Horns, which are 5 inches in diameter and weigh 12 pounds; and Squares, which are of various sizes and usually 3 or 4 inches thick. The cheese may be white or colored yellow, and it may be almost fresh or thoroughly ripened and broken down. It is made from sweet, skimmed, unskimmed, or partly skimmed milk of cows. When made of unskimmed milk it is called "full cream"; when otherwise, it is called "part skim" or "skim."

The milk, morning's and evening's mixed, is set at 85° F. with sufficient rennet to coagulate to the proper point in from 25 to 40 minutes. At the time of setting the milk should have an acidity of about 0.18 or 0.20 per cent. Color may or may not be used. The curd is cut when it breaks evenly before the finger. The cutting is done with curd knives made up of blades set about one-third of an inch apart in frames. In one frame the knives are set perpendicularly and in the other horizontally. When well cut the curd is in uniform cubes of about one-third of an inch.

After cutting, the curd is heated slowly and with continued stirring until it reaches a temperature of from 96° to 108° F. With the use of mechanical agitators, as is the common practice, the curd should be heated about 4° higher than when stirring is done by hand. After heating, the stirring is continued

intermittently until the curd is sufficiently firm. This is determined by squeezing a handful, which should fall apart immediately on being released. The whey is then drawn. At the same time the acid should have reached about 0.20 per cent, or one-fourth of an inch, on the hot iron, which latter is determined by measuring the length of strings when the curd is touched to a hot iron. The curd is then matted about 4 inches deep, sometimes in the bottom of the vat, sometimes on racks covered with a coarse linen cloth. After it has remained there long enough to stick together it is cut into rectangular pieces easy to handle, which are turned frequently and finally piled two to four deep; in the meanwhile the temperature of the curd is kept at about 90° F. When the curd has broken down until it has the smooth feeling of velvet, which requires from one to three hours, it is milled by means of a machine, which cuts it into pieces the size of a finger. It is then stirred on the bottom of the vat until whey ceases to run, which requires from one-half to one and one-half hours, when it is salted at the rate of 2 or 2½ pounds of salt to 100 pounds of milk. It is then ready to be put into the press. The curd is put into tinned-iron hoops of the proper size, which are lined with cheesecloth bandages. The hoops are put into presses and great pressure is applied by means of screws. The next morning the cheese is removed from the hoops and put on shelves in a curing room. Formerly it was kept in a curing room as long as six months, but at the present time it is covered with a coat of paraffin and put into cold storage when from 3 to 12 days old. There is a growing demand on the part of consumers for mild cheese, and consequently ripening must be carried on at a temperature below 50° F.

An important point in the process of manufacturing Cheddar cheese is the development of the desired quantity of acid. A maximum quantity in the whey that can be developed without injuring the texture of the cheese is aimed at, and the proper breaking down of the curd before milling and salting is attributed to the acid. It is very probable that too much weight has been placed on the desirability of a maximum development of acid, and that practically as good cheese can be produced without the high acid.

Some of the details in the manufacture of Cheddar cheese are varied to some extent, and other names may be used to designate the cheese so made. A stirred-curd cheese is one in which the curd particles are not allowed to mat together after the whey is drawn. The curd is stirred occasionally to prevent this matting process, but it differs from the sweet-curd cheese, as acid is allowed to develop before salting and pressing. Formerly there was a comparatively large quantity of stirred-curd cheese made, but very little, if any, is made at the present time.

A washed-curd cheese varies from the regular Cheddar process in having the milled curd subjected to cold water for a short period. This process is evidently practiced to force the curd to take up a small percentage of the water and increase the yield. It results in a cheese which apparently breaks down or ripens much more rapidly than cheese made in the ordinary way. This ripening is very likely not due to the excess of moisture, but to some other unexplained reason. Some States have prohibited the use of the State brand on washed-curd cheese.

CHESHIRE.

This cheese is one of the oldest and most popular of the English varieties. It is a rennet cheese made from cows' milk, unskimmed, and is named for Chester County, England, where it is largely produced. It is made in cylindrical shape, from 14 to 16 inches in diameter, and weighs from 50 to 70 pounds. In making this cheese sufficient annatto is used to give the product a very high

color. The process of manufacture varies in detail in different sections. Perfectly sweet milk, night's and morning's mixed, is set at a temperature of from 75° to 90° F. The curd is cut in one hour, usually with an instrument in which knives are set in a frame to cut cubes 1 or 1¼ inches square. This is pushed down through the curd and finally worked back and forth at an angle. This is continued for about an hour, or until the particles of curd are the size of peas. The curd is then allowed to settle and mat on the bottom of the vat for about an hour, when it is rolled up to one end, weighted down, and the whey drawn, after the desired degree of acidity has been obtained. The curd is cut in pieces the right size to handle and is piled on racks. It is then run through a curd mill, salted at the rate of 3 pounds to 1,000 pounds of milk, and put into a hoop having a number of holes in the side, through which skewers can be thrust into the cheese to promote drainage. The cheese in the hoop is put into a heated wooden box called an oven, and sometimes light pressure is applied, the pressure increasing gradually until it reaches about 1 ton. The curing cellar or room is about 60° to 65° F. The time required for thorough ripening is from 8 to 10 months.

CHESHIRE-STILTON.

This is a combination of the Cheshire and Stilton varieties of cheese, in which the general characteristics of size and shape and manufacture of the Cheshire are retained, and a growth of the mold peculiar to Stilton is secured. The mold is produced by keeping out each day a small portion of curd and mixing it with some in which the mold is growing well.

CHHANA.

This is a sour-milk cheese made in Asia from cows' milk, unskimmed.

CHIAVARI.

This is a sour-milk cheese made in the region of Chiavari, Italy, from whole milk of cows. It is also known as Cacio Romano. A hard, rennet cheese made in the same region is also known by this name.

CLUB.

This cheese very probably originated in the United States. It is prepared usually from well-ripened Cheddar cheese by grinding very fine and mixing with butter, condiments, spirits, etc. In the past, when prepared commercially, it has been put into small porcelain jars. At the present time much of it is wrapped in waxed paper and foil and is called "Snappy" cheese. Sometimes pimientos are mixed with this cheese, when it is called pimiento cheese. The factories add no butter in the standard brands of Club cheese.

COMMISSION.

This cheese is made in Holland and resembles Edam in the process of manufacture, but it has a slightly different shape, being flattened at the ends. It is said to be made from cows' milk, whole.

COOKED.

This kind of cheese is so called because in its manufacture the curd is heated to the melting point. It is made from fresh curd prepared by breaking up and heating the curd of sour, clabbered milk. When cooled sufficiently the curd is placed in a receptacle and allowed to stand for three or four days until it has

become colored throughout. It is then put into a kettle over a fire; salt, milk, and usually caraway seed are added, and the whole is stirred vigorously until it becomes of the consistency of thick molasses, or until it strings when a spoon is withdrawn from it. The mass can then be put into molds to remain until it becomes cold, or placed in a vessel for keeping. It gets hard with cooling and will retain the shape of the mold.

Cooked cheese, made in northern Germany, is called Topfen, and a similar product made in Sardinia is called Freisa, and Paneddas. The same kind of cheese made in Belgium is called Belgian cooked cheese. Similar kinds are made in other countries.

COTTAGE.

This is a sour-milk cheese made extensively in this country, where it is often called Dutch cheese, or Smearcase. It is manufactured usually in a very small way, but occasionally it is made in large factories. Skim milk is allowed to sour, and the curd is then broken up and held at a temperature of about 100° F. for about half an hour, or until it has become sufficiently firm. The whey is then drained off and the curd placed under slight pressure for a certain time. The curd is either consumed immediately or is packed in tubs and placed in cold storage. Sometimes it is made up into shapes and wrapped in tin foil. It is prepared for eating by moistening with either milk or cream. No ripening is ever allowed.

COTHERSTONE.

This is a rennet cows' milk cheese made in Yorkshire, England, and resembles the well-known Stilton cheese of that country. It is a local product manufactured only on a small scale. It has also been known as Yorkshire-Stilton.

COULOMMIERS.

This is a small-sized Brie cheese, 5 or 6 inches in diameter, 1 inch in thickness, and weighs about 1 pound. It is made in the region of Coulommiers, France.

CREAM.

Genuine cream cheese is made from a rich cream thickened by souring, or from sweet cream thickened with rennet. This is put into a cloth and allowed to drain, the cloth being changed several times during the draining, which requires about four days. It is then placed on a board covered with a cloth, sprinkled with salt, and turned occasionally. It is ready for consumption in from 5 to 10 days.

Another variety of cream cheese is made from cream with a low content of fat (6 or 8 per cent). One per cent of a lactic-acid starter is added to the cream, and after warming the mixture to 70° F. and thoroughly stirring, rennet is added at the rate of from 1 to 1½ ounces of commercial liquid rennet to 1,000 pounds of cream. Usually the cream is placed in shotgun cans holding about 30 pounds each. After setting for about 18 hours, the curd is poured, with as little breaking as possible, upon draining racks covered with cloths. After a few hours' drainage the cloths are drawn together, tied, placed upon cracked ice, and allowed to remain overnight. The curd is then pressed, salted, and worked to a paste by means of special machinery or by suitable substitutes. The cheese is then molded into pieces weighing from 3 to 4 ounces, wrapped in tin foil and, without curing, placed upon the market. The standard package of cream cheese is 3 inches by 2 inches by 1 inch. It is a mild, rich cheese which is

relished most when eaten a few days after it is made. Cream cheese is now quite extensively made in the larger factories of the United States, where the ever-increasing demand for it makes it one of the most popular varieties of soft cheese.

A so-called double-cream cheese, known in France as Fromage Double Crème, is made by coagulating a mixture of milk and cream, putting it into a cloth, and allowing it to drain thoroughly, when it is salted, kneaded, and molded into any desired shape. It is eaten fresh. The Gervais is a cheese of this kind.

A French cream cheese, Fromage à la Crème, is prepared by mixing sweet cream with well-ripened sour-milk curd or rennet curd. Another French cream cheese, which contains considerable salt as a preservative, is known as Demi-sel.

CREUSE.

This is a skim-milk, farm cheese made in the department of the same name in France. Coagulation is produced either by the addition of a small quantity of rennet or by heating the sour milk. When set with rennet, the period required is usually 12 hours. The curd is put into earthenware molds about 7 inches in diameter and 5 or 6 inches in height, the bottom and sides being perforated. After draining for several days the cheese is removed from the molds, salted, and frequently turned. In time it becomes very dry and hard and may be preserved for a year or even longer. The cheese is also ripened by placing in tightly closed receptacles lined with straw, in which case it becomes yellow and soft and acquires a very pronounced taste.

CRISTALINNA.

This is a hard, rennet cheese made from cows' milk in the Canton of Graubunden, Switzerland.

DAMEN.

This is a soft, uncured, rennet cheese made from cows' milk in Hungary and is much in demand in the markets of Vienna. It is sometimes known as Gloire des Montagnes.

DANISH EXPORT.

This cheese is made in some of the creameries of Denmark to furnish an outlet for the skim milk and the buttermilk. In the process of manufacture as high as 15 per cent of fresh buttermilk is added to the skim milk. The mixture is set at 98° F., with sufficient rennet to coagulate it in 25 minutes. The curd is carefully and evenly cut, stirred for a few minutes, dipped into forms having rounded bottoms, kneaded, pressed down, and finally covered with a board upon which a weight is placed. Twelve hours later the cheeses are placed in a brine tank for 24 hours, when they are taken out and covered with salt for a short time. They are then transferred to the ripening room, where the temperature is about 55° F., and are turned and wiped with a cloth every day for five weeks. The cheeses are small, flat, and cylindrical.

DERBYSHIRE.

This is a hard, rennet cheese made from cows' milk, whole, in Derbyshire, England. It is cylindrical in shape and about the size of the Cheshire, though often smaller. It is made usually in farm dairies, and because of this fact the size varies with the size of the herd. The quality also varies to such an extent that very few really good cheeses can be found. Night's milk in which the

development of acid has been prevented as much as possible is mixed with the morning's milk, and the whole is set at a temperature of 80° F. The setting period is one hour, and the curd is allowed to become very firm before cutting. It is cut to the size of a pea and after being allowed to settle is piled in the center of the vat, where, after the whey is removed, it is subjected to light pressure. The curd is cut and again piled and heavier pressure applied. This is repeated until the curd reaches a certain degree of firmness, when it is run through a mill and salted at the rate of 1 pound of salt to 1,000 pounds of milk. It is then put into a press for one hour, when it is removed and the surface of the cheese scalded for one minute in water heated to 150° F. It is put back into the press for five hours, the pressure applied being gradually increased, when it is salted on the surface and again pressed. The pressing continues for three days, the cheese being salted each day. The curing room is kept preferably at 60° F., and the time required for curing is from three to four months.

A cheese called Gloucester, made in the county of Gloucester, England, is said to be identical with Derbyshire cheese. Double Gloucester is identical with single Gloucester in all respects but size. It is twice as thick as a single Gloucester; hence the name. Wiltshire, Leicestershire, and Warwickshire cheeses belong to the Derbyshire type.

DEVONSHIRE CREAM.

In making this cheese the cream is allowed to rise for several hours, when the milk with the layer of cream is scalded. It is then set away for a short time in order that the layer of cream may harden. The cream is then put into small molds and placed upon straw mats to drain. After becoming hard enough to retain its shape, it is ready for market.

DORSET.

Dorset, or Dorset Blue, or blue Vinny, belongs to the group of hard-pressed cheeses, deriving its name from the county in England where it was first made, and also from the blue mold which develops as the cheese ripens. Its manufacture has been traced back 150 years in the family of F. E. Dare, who says that in all probability it was made longer ago than that.

DOTTER.

This cheese is said to have been made by G. Leuchs, in Nürnberg, by mixing the yolk of eggs with skim milk and making this mixture into cheese in the usual way.

DRY.

This cheese, known also as Sperrkäse and Trockenkäse, is made in the small dairies of the eastern part of the Bavarian Alps and in the Tyrol. It is an extremely simple product, made for home consumption, and only in the winter season, when the milk can not be profitably used for other purposes. As soon as the milk is skimmed it is put into a large kettle which can be swung over a fire, where it is kept warm until it is thoroughly thickened from souring. It is then broken up and cooked quite firm. A small quantity of salt and sometimes some caraway seed are added, and the curd is put into forms of various sizes. It is then placed in a drying room, where it becomes very hard, when it is ready for eating.

DUEL.

This is a soft-cured, rennet cheese made from cows' milk. It is an Austrian product, 2 by 2 by 1 inches in size.

DUNLOP.

This was formerly the national cheese of Scotland, but it has been almost superseded by the Cheddar, which it resembles.

EDAM.

This is a hard, rennet cheese produced in Holland; it is also known as Katzenkopf, Tête de Maure, and Manbollen. The best of the product is made of cows' milk, unskimmed, but much of it at the present time is made from milk which has had at least one-half of the fat removed. The cheeses are round and are colored deep red on the surface or wrapped in tin foil.

The perfectly fresh milk is set at 90° or 95° F. Color is added, and sufficient rennet is used to coagulate the milk in 15 minutes. The curd is cut and after a very short stirring is allowed to settle to the bottom, when the whey is dipped off. The curd is gathered in a pile, and pressure is applied for a short time to expel the whey. Care is taken in the meanwhile that the curd does not get below 82° or above 90° F. The curd is then ready for the press. Sometimes wooden molds are used, but the best are made of iron. An attempt is made to put just sufficient curd into the mold to make a perfect sphere when pressed. When the mold is half full a little salt is added; when it is full, the cheese is pressed lightly until it will hold its form, when it is taken out and immersed in water for two minutes at 125° F. The cheese is then put into the press, where it remains for 12 hours. It is then removed from one mold and placed in another form resembling the mold, but without a cover, and having a hole leading from the bottom. The cheese is salted by rubbing salt on the surface. Sometimes it is kept in a salt bath for a day before putting salt on the surface. Following the salting, the cheese is washed in hot whey, and the surface is scraped smooth. It is then taken to the ripening cellar, which should have a temperature of between 50° and 70° F. Here it is turned daily for a time and finally twice a week. In the meantime it is occasionally moistened with cold water or fresh beer. When the cheese is one month old it is washed in water at 70° F. for 20 minutes and then placed in the sun to dry, after which it is rubbed with linseed oil. Before shipping, the cheese is colored, usually red, but for some markets it is colored yellow with annatto. The red coloring is done with a watery solution of litmus and Berlin red, or with carmine. A considerable quantity of this cheese is imported into the United States. At the present time Holland exports some Edam cheeses inclosed in air-tight tins.

EGG.

Egg cheese, made in the Province of Nyland, Finland, described by Prof. Casta Grotenfelt and reviewed by Monrad in Hoard's Dairyman, is made from fresh eggs, from 2 to 12 added to 6 quarts of new milk. Usually they are whipped into a starter, but sometimes half of them are added before coagulation and the other half after drawing the whey. The best are made with a cream starter. Monrad appears to be rather skeptical about this kind of cheese and says it should be labeled "Egg cheese" in order not to deceive the public.

ELBING.

This is a hard, rennet cheese made from cows' milk in West Prussia; in winter the milk is skimmed, but at other times it is used whole. It is known also as Werderkäse and Niederungskäse. Rennet enough is added to the milk at a temperature of 80° F. to coagulate it in from 15 to 30 minutes. The curd is cut

and cooked to 100° F., salted in the granular state, and pressed for 12 hours. A cheese is 10 or 20 inches in diameter and 3 or 4 inches in thickness. Ripening requires about one month at a temperature of 75° F.

EMMENTAL.

This is a hard, rennet cheese made from cows' milk, unskimmed, and has a mild, somewhat sweetish flavor. It is characterized by holes or eyes which develop to about the size of a cent in typical cheeses and are from 1 to 3 inches apart. Cheese of the same kind made in the United States is known as Domestic Swiss, and that made in the region of Lake Constance is called Algau Emmental. Other local names are Bellunese, Formaggio Dolce, Fontine d'Aosta, and Thraanen.

Emmental cheese originated in Canton Bern, Valley of Emmental, Switzerland, and is a very old variety. In the middle of the fifteenth century a cheese probably of this type was manufactured in the Canton of Emmental. In the middle of the seventeenth century the industry was well developed, and genuine Emmental cheese was exported. In 1722 its manufacture under the name of Gruyère is recorded in France, two cooperative societies having been organized for the purpose.

Emmental cheese is now manufactured in every civilized country. In the United States there are many factories, principally in Wisconsin, New York, and Ohio. In Switzerland the greater part of the milk produced is made into this product, and large districts in France and northern Italy are devoted to its manufacture. The best of the product made in Switzerland is exported, about 5,000,000 pounds coming to the United States annually. The imported cheese sells in this country at about 25 cents a pound wholesale, and the domestic cheese sells at about 14 cents. Practically as good cheese can be manufactured in the United States as in Switzerland, but prejudice, combined with the fact that much of the domestic product is sold as imported, has held the price at a low level.

There is a slight difference in manipulation of the milk in making Emmental cheese in this country as compared with Switzerland. In the latter country the evening's and morning's milk are made up together, while in the United States it is popularly believed that the evening's milk must be made into cheese immediately after milking, as is done with the morning's milk.

In making the cheese in Switzerland the evening's milk is skimmed; the fresh morning's milk is heated to 108° or 110° F., and the cream from the evening's milk is added and well stirred in. The evening's milk cooled with a little saffron to color it, is then added, and the whole is mixed. The milk is then brought to a temperature of 90° F. in summer and 95° F. in winter, and sufficient rennet is added to coagulate the milk in 30 or 40 minutes. The whole process is carried through in a huge copper kettle holding 300 gallons. The rennet used is the calf's stomach soaked in whey for 24 hours. When the milk has thickened to almost the desired point for cutting, which is practically the same as for ordinary American or Cheddar cheese, the thin surface layer is scooped off and turned wrong side up. This is supposed to aid in incorporating the layer of cream with the cheese. The curd is then cut very coarse by means of a so-called harp. The cheesemaker, with a wooden scoop in each hand, then draws the mass of curd toward him, that lying on the bottom of the kettle being brought to the surface. At this point the cheesemaker and an assistant commence stirring the curd with the harp, a breaker having first been fitted to the inside of the kettle to interrupt the current of the whey and curd. The harps are given

a circular motion and cut the curd very fine—about the size of wheat kernels or smaller.

After this stage is reached heating is commenced. In Switzerland until recently all the heating was done over an open fire, the kettle being swung on a large crane; most of the factories have the same method at the present time. In this country the same method was followed in the early days of the industry, but at the present time inclosed fireplaces, into which the kettle can be swung and doors closed to retain the heat, are largely employed. This takes away much of the discomfort of the operation. In a few instances the kettle is set in cement and an iron car containing the fire is run under it. The more modern factories use steam, which appears to be the most satisfactory way. When the heating is begun the contents of the kettle are brought rapidly to the desired temperature, which may be from 126° to 140° F., the higher temperature often being necessary to get the curd sufficiently firm. In the meanwhile the stirring continues for about one hour, with slight interruptions near the end of the process, when the curd has become so firm that it will not mat together. The end of the cooking is determined by the firmness of the curd, which is judged by matting a small cake with pressure by the hands and noting the ease with which the cake breaks when heating the edge.

When the curd is sufficiently firm, the contents of the kettle are rotated rapidly and allowed to come to a standstill as the momentum is lost. This brings all the curd into a cone-shaped pile in the center of the kettle. One edge of a heavy linen cloth resembling burlap is wrapped around a piece of hoop iron, and by this means the cloth is slipped under the pile of curd. The mass of curd is then raised from the whey by means of a rope and pulley and lowered into a cheese hoop on the draining table. These hoops are from 4 to 6 inches deep and vary greatly in diameter. The cloth is folded over the cheese, a large follower is put on top, and the press is allowed to come down on the cheese. The press is usually a log swung at one end and operated by a double lever. Pressure is continued for the first time just long enough for the curd mass to retain its shape. The hoop is then removed, the cheese turned over, and a dry cloth substituted. The cheese is allowed to remain in the press about 24 hours, during which time it is turned and a dry cloth substituted several times (six or more).

At the end of the pressing, the curd should be a homogeneous mass without holes. The cheese is then removed to the salting board, covered with a layer of salt, and occasionally turned. In a day or two it is put into the salting tank in a brine strong enough to float an egg; it remains there at the discretion of the cheesemaker for from one to four days. Often no brine tank is used with Emmental cheese.

The cheese is then taken to the curing cellar. In the best factories two or more cellars with different temperatures are available, and the cheeses are placed in them according to the way the cheesemaker thinks their development requires. If it appears that the cheese may develop too fast and have too many and too large eyes, it is placed in a cool cellar; if the reverse is true, a warm cellar is selected. The cellars vary in temperature from 55° to 65° F., though in extreme cases 70° F. or a little higher may be used. While the cheeses are in the ripening cellar, which in Switzerland may be from 6 to 10 months or longer, and in the United States three to six months, they should be turned and washed every other day for the first two or three months and less often subsequently, and at the same time a little coarse salt is sprinkled on the surface. In a few hours this salt has dissolved, and the brine is spread over the surface with a long-handled brush.

The cheeses are very large, about 6 inches in thickness and sometimes as much as 4 feet in diameter, and weigh from 60 to 220 pounds. In shipping, a

number of them are placed in a tub which may contain 1,000 pounds of cheese. Sometimes Emmental cheese is made up in the form of blocks instead of the shape of millstones. The blocks are about 28 inches long and 8 inches square in the other dimensions.

ENGADINE.

This is made in the Canton of Graubünden, Switzerland, and is a rennet cheese made from cows' milk, unskimmed.

ENGLISH DAIRY.

This name is applied to a very hard cheese, made in the same general way as Cheddar, but cooked much more. It has been made mostly in the United States and is used for culinary purposes.

ÉPOISSE.

This is a soft, rennet cheese made from whole or partly skimmed milk in the Department of Côte d'Or, France.

ERIWANI.

This cheese usually is made in the Caucasus from sheep's milk. The fresh milk is set at about 95° F., with sufficient rennet to coagulate it in 20 minutes. The curd is broken up, and the whole is put into a sack, allowed to drain, and then pressed with stones until the whey stops running. The cheese is salted in brine. Different local names are given to this product, Karab, Tali, Kurini, Elisavetpolen, and Kasach being mentioned.

ERVY.

This is a soft whole-milk, rennet cheese resembling Camembert and deriving its name from the village of Ervy, in the Department of Aube, France. It is about 7 inches in diameter, 2½ inches thick, and weighs about 4 pounds.

FARM.

This cheese, made in France, and known variously as Fromage à la Pie, Mou, Maigre, and Ferme, is essentially the same as our cottage cheese. The method of making is very simple. When the skimmed milk has become curdled, the whey is poured off and the curd kneeded and molded into various sizes and shapes. Draining is sometimes hastened by placing a board and weight upon the curd. Salt and sometimes sweet cream are added. The cheese is consumed usually on the farm where made, either while fresh or after it has undergone fermentation.

FILLED.

Filled cheese is the name applied to cheese from which the butterfat has been removed and foreign fats added. The foreign fat is added by stirring it violently in the milk and setting with sufficient rennet to coagulate quickly. The rest of the manufacture is the same as for Cheddar cheese. For a number of years filled cheese was very extensively manufactured in the United States, but State and Federal laws have made it no longer practicable. Many of the European varieties of cheese are counterfeited or adulterated in the same manner.

FLOWER.

This cheese is so named because it is made with the addition of the petals of various kinds of flowers, such as roses or marigolds. It is a soft-cured rennet cheese made in England from cows' milk, whole.

FOREZ.

This cheese, sometimes called d'Ambert, is made in central France. The process is said to be very crude and the ripening unusual. The cheeses are cylindrical in shape, 10 inches in diameter and 6 inches high. They are ripened by placing them on the floor of the cellar, covering them with dirt, and allowing water to trickle over them. Many are spoiled by the unusual growths of mold and bacteria. The flavor of the best of them is said to resemble that of Roquefort.

FORMAGELLE.

This is a small, soft-ripened rennet cheese made from cows' milk in the northwestern part of Italy.

FORMAGGINI.

This name is applied to several kinds of small Italian cheeses. The kind designated Formaggini di Lecco is a small, cylindrical dessert cheese, weighing about 2 ounces, made in the region of Lecco, in Lombardy. It is consumed while fresh and sweet and at all stages of ripening until it becomes very piquant. Sometimes salt, pepper, sugar, and cinnamon are mixed with it, and occasionally oil and vinegar are added. The method of manufacture is not essentially different from that of other soft cheeses. At times cows' milk is used with the addition of some goats' milk. Rennet is added to the warmed milk, which is then allowed to stand for 24 hours at a temperature of about 55° F. The curd, with as little breaking up as possible, is allowed to drain for three or four hours, when it is salted and put into cylindrical molds about 1¼ inches in diameter and 2 inches high.

FROMAGE FORT.

Several kinds of cooked cheese prepared in France are known by this name. In the Department of Ain, Fromage Fort is prepared by melting well-drained skim-milk curd, putting the melted mass into a cloth, and subjecting it to pressure and afterward burying it in dry ashes in order to remove as much of the whey as possible. The mass is then grated fine and allowed to ferment for 8 or 10 days, after which milk, butter, salt, pepper, wine, etc., are added to it, and the mixture is allowed to undergo further fermentation.

Canquillote, Cancoillotte, or Fromagère, prepared in the eastern part of France, is a cheese of this kind, as is also the Fondue, or cooked cheese, of Lorraine.

FRÜHSTÜCK.

This is a Limburg type of cheese, made in round shape about 2½ or 3 inches in diameter. It goes also by the name Breakfast or Lunch cheese.

FTINOPORINO.

This is a Macedonian cheese similar to Brinsen, and is made from sheep's milk.

GAMMELOST.

Gammelost is made in Norway from skimmed sour milk. The milk is cooked or warmed in a kettle and allowed to stand for one hour, while the precipitated casein gathers at the bottom. This is taken up in a cloth, and the whole is put

into a form where light pressure is applied. The cheese, still in the cloth in the form, is put into the hot whey for an hour, when it is again placed under pressure for a short period. It is then put into a warm place and turned daily. At the end of 14 days it is packed in a chest with wet straw. The cheeses vary in weight from 24 to 65 pounds each.

GAUTRAIS.

This is a cylindrical cheese weighing about 5 pounds and very closely resembling Port du Salut. It is made in the Department of Mayenne, France.

GAVOT.

This cheese is made from cows', sheep's, or goats' milk in the Department of Hautes-Alpes, France.

GEHEIMRATH.

This is a deep-yellow-colored cheese made in small quantities in Holland and resembles a small Gouda cheese in quality and process of manufacture.

GÉROMÉ.

This is a soft, rennet cheese made in the mountainous regions of the Vosges, France. The name is a corruption of Gérardmer, a village in the region where the cheese has been made for at least 60 years. The variety is very similar to Münster but not so well known.

Cows' milk is used almost exclusively to make this kind of cheese, though at times a little goats' milk is added. The fresh milk is set with rennet at a temperature of about 80° or 90° F. In about one-half hour after adding the rennet the curd is cut into rather large cubes and allowed to stand for about one hour, when the whey is dipped off. The curd is then put into cylindrical forms or hoops 6 or 7 inches in diameter. Formerly these were made of wood, one being placed upon another, making a total height of 14 or 15 inches. They are now being made also of tin and in various sizes. The cheeses are turned after 6 hours and again after 12 hours. During the next two or three days they are turned twice daily, the hoops being changed each time. A room temperature of between 60° and 70° F. is desired during this process. The cheeses are then salted, the quantity of salt used being from 3 to 3.5 per cent of the weight of the cheese.

The cheeses are then placed in a well-ventilated room for several days and when sufficiently dry are transferred to the curing cellar, where they are turned frequently and worked with warm salt water to prevent the growth of molds. Ripening requires from six weeks to four months, depending upon the size of the cheeses, which vary in weight from one-half pound to 5 pounds or more. Anise is sometimes incorporated with the curd before putting into the forms. This cheese when old often has a greenish appearance.

GERVAIS.

This is a French cheese made from a mixture of whole milk and cream. The mixture is set with rennet at about 65° F., the time required being about 12 hours. The curd is then inclosed in cloth and hung up to drain. When sufficiently dry it is salted and pressed into molds. The molds are soon removed, and the cheese is wrapped in paraffin paper. The cheese is usually consumed while fresh but may be kept for several days. Gervais is a cream cheese of the Neufchâtel group, made by the Maison Gervais, a French company with headquarters near Paris.

GEX.

This is a hard, rennet cheese made from cows' milk. It belongs to the class of blue or marbled cheese known in France as Fromage Persillé, which includes Sassenage, Septmoncel, and several other kinds resembling Roquefort. It is made principally in the southeastern part of France and derives its name from the town of Gex, in the Department of Ain, where the cheese has been made for at least 70 years. There has been little tendency for the industry to extend to other regions than that in which it originated, and even there it is said to be diminishing.

Rennet is added to the fresh milk as soon as possible after milking. The time allowed for coagulation is one and one-half or two hours. The curd is then broken up and stirred until the mass is in a semiliquid condition, when it is allowed to stand for about 10 minutes. After the curd has settled to the bottom of the vat the whey is drained off. The curd is then worked by hand, salted lightly, and put into hoops about 12 inches in diameter and 5 inches in height. In about one hour the cheese is turned and a disk and weight placed upon it. The turning is repeated three or four times a day, the hoops being removed at the end of the first day. After salting, the cheese is taken to the curing room, where it soon acquires a bluish appearance, due to the development of a penicillium. During the making this mold is not introduced into the interior of the cheese by means of mottled bread, as in the case of Roquefort cheese. The ripening process, which requires from three to four months, is completed in cellars or natural caves. A ripened cheese weighs from 14 to 15 pounds.

GISLEV.

This is a hard, rennet cheese made in Denmark from cows' milk, skimmed.

GLUMSE.

This cheese is made from sour, skimmed milk in western Prussia. The thickened milk is placed over a slow fire at about 105° F. and is cooked as long as any whey is expelled. The cooking may be done by pouring hot water into the milk. After cooking, the curd is removed from the whey with a perforated dipper and is allowed to drain in a hair sieve. Milk or cream is added to the cheese just before eating. This is evidently a cottage cheese.

GOATS' MILK.

There are a large number of goats'-milk cheeses, many of which are not designated by local names. In France some of these cheeses are known by the names Chevret or Chevrotin, in Italy as Formaggio di Capra, and in German-speaking countries as Ziegenkäse or Gaiskäsli. Among those in France to which local names have been attached are Gratairon, Lamothe, and Poitiers.

The Gaiskäsli is a soft cheese made in certain parts of Germany and Switzerland. The milk is set with sufficient rennet to coagulate it in about 40 minutes. The curd is then broken up, stirred, and dipped into cylindrical molds about 3 inches in diameter. This mold is filled sufficiently to make a cheese 1½ or 2 inches thick and weighing one-half pound. The mold is set on a straw mat which allows the whey to drain freely, and salt is sprinkled on the surface. In two days the cheese is turned, and the other surface is salted. The cheese requires about three weeks to ripen and is said to have a very pleasant flavor.

A kind of cheese is made in Norway by drying goats' milk by boiling, fresh milk or cream sometimes being added during the process.

GORGONZOLA.

This variety, known also as Stracchino di Gorgonzola, is a rennet, Italian cheese made from whole milk of cows. The name is taken from the village of Gorgonzola, near Milan, but very little of this cheese is now made in that immediate locality. The interior of the cheese is mottled or veined with a penicillium much like Roquefort, and for that reason the cheese has been grouped with the Roquefort and Stilton varieties. As seen upon the markets in this country the surface of the cheese is covered with a thin coat resembling clay, said to be prepared by mixing barite or gypsum, lard or tallow, and coloring matter. The cheeses are cylindrical in shape, about 12 inches in diameter and 6 inches in height, and as marketed are wrapped in paper and packed with straw in wicker baskets.

The manufacture of Gorgonzola cheese is an important industry in Lombardy, where formerly it was carried on principally during the months of September and October, but with the establishment of curing cellars in the Alps, especially near Lecco, the manufacture is no longer confined to those months.

The milk used in making this cheese is warmed to a temperature of about 75° F. and coagulated rapidly with rennet, the time required being usually from 15 to 20 minutes. The curd is then cut very fine, inclosed in a cloth and drained, after which it is put into hoops 12 inches in diameter and 10 inches high. It was formerly the custom to allow the curd from the evening's milk to drain overnight and to mix it with the fresh, warm curd from the morning's milk prepared in the same way. The curd from the evening's milk and that from the morning's milk, crumbled very fine, were put into hoops in layers with moldy bread crumbs interspersed among the layers. The cheese is turned frequently for four or five days, the cloths being changed occasionally, and is salted from the outside, the process requiring about two weeks. It is then transferred to the curing rooms, where a low temperature is usually maintained. At an early stage in the process of ripening, the cheese is usually punched with an instrument about 6 inches long, tapering from a sharp point to a diameter of about one-eighth inch at the base. About 150 holes are made in each cheese. This favors the development of the penicillium throughout the interior of the cheese. Well-made cheese may be kept for a year or longer. In the region where it is made, much of the cheese is consumed while in a fresh condition.

GOUDA.

This is a Holland cheese made from cows' milk whole or partly skimmed. It is round and weighs from 10 to 45 pounds. The milk, to which coloring matter has been added, is set at 91° F. with sufficient rennet to coagulate it in 15 minutes. The curd is cut or broken with a wooden scoop, a harp, or an American cheese knife. It is allowed to stand for a minute, and the whey is dipped off. Hot whey or hot water is poured on the mass of curd until the whole has reached a temperature of 104° to 110° F. When the curd squeaks or whistles if it is crushed between the teeth the whey or water is dipped off and the curd is stirred and piled where it will drain well. The curd is then thoroughly kneaded and sometimes lightly salted. After salting, the curd is put into round molds and placed in a press, where it remains for 24 hours with increasing pressure. The cheese is then salted, either by immersion in brine or by rubbing salt on the surface. The salting continues from four to eight days, after which the cheese is washed with hot whey and is transferred to the ripening cellar, where it is turned daily for several days and finally once a week until

ripened. In six or eight months it is ready for consumption. When the cheese is a few days old it is washed with water and colored with saffron. Some of this cheese is shipped to the United States. As seen in this country, each cheese is covered with an animal tissue said to be a bladder.

GOURNAY.

This is a soft, rennet cheese which derives its name from the village of Gournay in the Department of Siene-Inférieure, France, where it is made. It is about 3 inches in diameter and three-fourths inch thick.

GOYA.

This cheese is manufactured in the Province of Corrientes, in the Argentine Republic. Either whole or partly skimmed milk is used. It is heated to a temperature of 75° or 85° F. and coagulated with rennet in from 15 to 30 minutes. The curd is cut and put into sacks to drain, after which it is put into molds.

GRANULAR CURD.

This cheese resembles the genuine Cheddar-process cheese in all points, except that it is not matted and milled. As soon as the curd is cooked firm enough it is salted and pressed. Because no acid is developed between cooking and pressing, a little more acid may be allowed to develop before drawing the whey, and the curd should be cooked firmer.

GRAY.

This is a sour, skim-milk product of the Tyrol. When the milk is thickened, the curd is brought to a proper firmness by light heating and is then dipped into a cheesecloth, care being taken that the flocculent matter at the bottom of the kettle is thoroughly mixed with the rest of the curd in order to insure an even product. The curd is put under a press for 10 minutes, when it is broken up by hand or in a mill and salt and pepper are added. The curd is then put into forms or hoops, and to insure the proper ripening a little well-ripened, gray cheese, grated, is added, or bread crumbs with the characteristic mold growth are mixed with the curd as it is put into the forms. The forms are made in various shapes and sizes and are supplied with holes to facilitate drainage. The cheese remains in the forms under pressure for 24 hours and is then taken to the drying room, which has a temperature of 70° F. The length of time it should remain in the drying room is determined by the appearance of the cheese. It is then taken to the ripening cellar. When ripened, the cheese has a pleasant taste and a gray appearance throughout the entire mass.

GRUYÈRE.

This name is applied to Emmental cheese manufactured in France, the name originating from the Swiss village of Gruyère. The cheese was first mentioned in 1722, when two societies were reported to have been organized for its manufacture. The Gruyère cheese is made in three different qualities—whole milk, partly skimmed, and skimmed. It is usually made from partly skimmed milk, a fact that is supposed to distinguish it from Emmental, which is supposed to be made from whole milk. The manufacture of Gruyère cheese is an extensive industry in France, about 50,000,000 pounds having been manufactured annually the latter part of the last century.

GÜSSING.

This is an Austrian skim-milk cheese weighing from 4 to 8 pounds. It resembles very much the Brick cheese of the United States and is made in practically the same way.

HAND.

Hand cheese is so named because originally it was molded by hand into its final shape. It is a sour-milk cheese, very popular among German races, and manufactured in many countries.

The process of making varies in different localities, but in general is about as follows: The skimmed milk is mixed with buttermilk and put into a tinned vessel, where it is held at a favorable temperature for souring. When thick the curd is broken up by stirring and heated to 120° F. The cooking is continued for about three hours, and for the first hour of this time the curd is stirred thoroughly. After cooking, the whey is drained off and the curd is put into a mold for cooling. It is then ground fine in a curd mill, salt is incorporated, and in some kinds of caraway seed is added. The curd is then pressed into the desired shapes and sizes. The small cheeses are dried in a warm room and then transferred to the curing cellar, where they are kept on shelves until the ripening on the surface has commenced, when they are packed in boxes. The cheese has a very sharp, pungent odor and taste, which is very disagreeable to most people unaccustomed to it.

There are many local names for hand cheeses, among which are the following: Thuringia Caraway cheese; Ihlefeld, made in Mecklenburg; Livlander, made in Russia; Olmützer Bierkäse; Dresdener Bierkäse; Satz, made in Saxony; Tyrol sour cheese; Berliner Kuhkäse; and Alt Kuhkäse.

HARZ.

This is a hand cheese made in different sizes. It is 1½ by 2½ inches in diameter, from one-fourth to three-fourths inch in thickness and weighs one-fourth pound. In manufacture it is identical with hand cheese.

HAY.

This cheese, known as Fromage de Foin, is a skim-milk variety made in the Department of Seine-Inférieure, France. It derives its name from the fact that it is ripened on as freshly cut hay as possible, which gives a characteristic aroma to the cheese. In some respects it resembles a poor grade of Livarot. It is about 10 inches in diameter and 2 or 3 inches thick.

The milk is set with rennet at a temperature of 80° or 85° F. In about one hour the curd is cut and the whey removed; the curd is then pressed to remove as much of the whey as possible, after which it is pressed by hand into molds. After draining for about two days it is put into the drying room, where it remains for about three weeks, when it is taken to the curing cellar and buried in hay. After remaining there for from six weeks to three months it is ready for sale. The consumption of this variety is largely restricted to the region where it is made.

HOHENHEIM.

This is a soft cheese made in Hohenheim from partly skimmed milk. It is cylindrical in shape, 4 to 6 inches in diameter, and weighs about one-half pound.

The evening's milk skimmed is added to the morning's milk and heated in a copper kettle to 110° F. Some saffron is used for color and rennet is added.

In one or one and a half hours the curd is broken up and the whey dipped off. Caraway seed is stirred in, which reduces the curd to smaller particles. For easy draining it is dipped into tin hoops, having holes, where it remains 12 hours and an additional 12 hours on a drying board. It is then sprinkled with salt; when the salt is dissolved the curd is again salted and placed in the curing cellar. To ripen requires three months.

HOLSTEIN HEALTH.

This is a cooked cheese made from sour skimmed milk, the local name being Holsteiner Gesundheitskäse. The milk is heated lightly and the curd is strongly pressed; it is then well mixed and put into a tin kettle. A little cream and salt are added, and the whole is stirred while it is being heated to the melting temperature over a fire. It is then put into a hoop or mold, which holds about one-half pound, and is allowed to cool.

HOLSTEIN SKIM MILK.

As the name indicates, this is a skim-milk cheese made in the Province of Holstein, where it is known as Holsteiner Magerkäse. Usually in the manufacture of this cheese 6 per cent of buttermilk is added to separator skim milk. A part is heated to 166° F., and the remainder is mixed with the pasteurized portion. The milk is colored with saffron, and rennet powder is used for coagulating the casein, which requires about 35 minutes. The curd is then broken up and allowed to remain in the whey for 30 minutes without stirring. A cloth is then used for lifting the curd from the whey, and 1 per cent of salt is mixed in. The curd is pressed for one-half hour, when it is turned and pressed again. The pressure is gradually increased from 5 pounds to 9 pounds for each pound of cheese. The cheese is transferred to the curing cellar, which has a temperature of 60° F. It is there turned daily until ripened, which requires four months. Each cheese weighs from 12 to 14 pounds.

HOP.

Hop or Hopfen cheese is a German product. The ground curd is salted and allowed to ripen for three or four days, when it is mixed with fresh curd and molded into small cheeses measuring about 2½ inches in diameter and 1 inch in thickness. These cheeses are placed in a well-ventilated room and allowed to become quite dry, when they are packed in hops.

HVID GJEDEOST.

This is a goats'-milk cheese made in Norway. The milk is set at 70° F. or higher. The curd is broken up and cooked in the usual manner, after which it is pressed in forms 9 or 10 inches long, 6 inches broad, and 4 inches high. It is made only for local consumption.

ILHA.

Ilha is a Portuguese word meaning island, and is applied to the cows'-milk cheese made in the Azore Islands and imported quite extensively into Portugal. They are moderately firm cheeses, measuring 10 or 12 inches in diameter and about 4 inches in thickness.

INCANESTRATO.

This name is applied to cheese made in Sicily. The mixture of evening's and morning's milk is curdled with rennet in about three-fourths of an hour. The curd is then stirred thoroughly and 2 per cent of water added. After standing

for five minutes the curd is separated from the whey, pressed by hand, and sometimes allowed to ferment for two or three days, when it is cooked in whey and then pressed and salted. Various spices are added. A kind known as Majocchino, made in the region of Messina, of cows', goats', or sheep's milk, contains olive oil.

ISIGNY.

This is an American cheese originating about 40 years ago in attempts to make Camembert cheese in this country. The proper ripening for Camembert cheese was not obtained, and hence a distinct name was given to the product. The cheese is slightly larger than Camembert, but of the same shape. The ripened product bears a close resemblance to Limburg. The process of manufacture is similar to that of Camembert. During ripening, however, the cheese is washed and rubbed occasionally to check the growth of molds on the surface.

JACK.

Jack cheese was first made in Monterey County, Cal., about 35 years ago and was then called Monterey cheese. Its manufacture under that name is still limited to that State, but its method of manufacture agrees closely with the granular-curd method for Cheddar cheese. Morning's milk is mixed with evening's milk and warmed in a vat to from 86° to 88° F., and rennet extract is added at the rate of 6 or 8 ounces per 1,000 pounds of milk. No coloring matter is used. It is ready for the curd knife in about half an hour, its readiness being determined as in Cheddar cheese. The cutting is done with a curd knife, the product then being stirred by hand or by rake. The curd is heated to from 98° F. in winter to 105° or 110° F. in summer. After the temperature is up the cheese is stirred occasionally with the rake until the whey is drawn at 0.14 or 0.15 per cent acidity. The curd is then stirred thoroughly to keep it from matting and is salted at the rate of 1½ pounds to 100 pounds of curd, the whole being thoroughly stirred. During the salting process cold water is run under the vat, the hot water having been previously run off.

The curd, no hoops being used, is put into press cloths at a temperature of 80° or 85° F. One gallon of curd is put into each cloth, making a cheese weighing 6½ pounds. With one hand the corners of the cloth are caught up tight, the cheese being pressed and rolled with the other hand. The cheese is then pressed overnight and placed in the curing rooms for three weeks before being ready to ship.

JOCHBERG.

This cheese is made from a mixture of cows' and goats' milk in the Tyrol. The cheese weighs 45 pounds and is 20 inches in diameter and 4 inches high.

JOSEPHINE.

This is a soft-cured, rennet cheese made in Silesia from cows' milk, whole, and is put up in small cylindrical packages.

KAJMAK.

The Turkish word Kajmak signifies cream and is used to designate a product made in Servia and sometimes known as Servian butter. This product, however, is analogous to a cream cheese. The milk is boiled and put into large, shallow vessels, usually of wood, and allowed to stand for 12 hours, when the cream is removed and usually salted. The flavor varies greatly with the age

of the sample and is said to be between that of a goats'-milk cheese and Roquefort.

KARUT.

This is a very dry, hard, skim-milk cheese, made in Afghanistan and northwestern India.

KASCAVAL.

This is a loaf-shaped rennet cheese weighing from 4 to 6 pounds, made from sheeps' milk in Bulgaria, Roumania, and Transylvania. Goats' milk is sometimes added. Considerable quantities of the cheese are exported.

KATSCHKAWALJ.

This is a sheep's-milk cream cheese made in Servia. The milk is curdled with rennet, and the curd is drained and inclosed in tin cans which are put into boiling water. The curd is subsequently worked by hand and molded into various shapes. Ordinarily a cheese weighs about 6 pounds.

KJARSGAARD.

This is a hard, rennet cheese made in Denmark from cows' milk, skimmed.

KLOSTER.

This is a soft-ripened, rennet cheese made from unskimmed milk of cows. It has a somewhat unusual shape, 1 by 1 by 4 inches, and weighs less than one-fourth pound.

KOLOS-MONOSTOR.

This is a sheep's-milk, rennet cheese made in the agricultural school in Transylvania. The cheese is rectangular in shape, 8½ by 5 by 3 inches, and weighs 4 pounds.

KOLOSVARER.

This cheese is made from buffaloes' milk, and when ripened is said to resemble Trappist cheese.

KOPPEN.

Koppenkäse is a goats'-milk cheese made in Germany. The milk is set at 80° or 85° F., and after the whey has been dipped off the curd is put into a cup-shaped vessel which gives form to the cheese and also the name. The cheese is placed in a warm room and sprinkled with salt. It is allowed to dry for from two to three days and is then placed in the ripening room. The ripened cheese weighs from 3 to 4 ounces, and has a sharp, pungent, slightly smoky flavor.

KOSHER.

This cheese under various names is made in several countries. It is a cows'-milk rennet cheese made for the Jewish trade. The process of manufacture resembles that of Limburg. The cheese, however, is eaten fresh.

KOSHER GOUDA.

This is a cheese made especially for the Jewish trade. It is identical with a Gouda cheese in every way except in size and in having no bladder covering. It weighs from 4 to 6 pounds and is 8½ inches in diameter and 3 inches thick.

It bears a stamp by which the Jewish consumer identifies it. Small quantities are imported into this country.

KRUTT.

Krutt, or Kirgischerkäse, is made by the nomadic tribes of the middle Asiatic Steppes from sour skim milk of the cow, goat, sheep, or camel. When the milk coagulates, salt is added and the curd is hung up in a sack to drain, after which it is subjected to moderate pressure. The curd is then made up into small balls, which are placed in the sun to dry.

KUHBACH.

This is a soft-ripened, rennet cheese made from cows' milk, either whole or partly skimmed. It is a German product, made in upper Bavaria. It is cylindrical in shape, weighs 2 pounds, and is 6 inches in diameter and 3 inches high.

LAGUIOLE.

This is a hard rennet cheese varying but little, if any, from Cantal, and resembling Roquefort. It derives its name from the village of Laguiole in the Department of Aveyron, France. The cheese is made extensively in the mountains of Aubrac, where it is said to have been made at the time of the Roman occupation. The milk, either whole or partly skimmed, is set with rennet, the time allowed being about 30 minutes. The curd is allowed to ferment for about 24 hours and is then put into hoops and pressed. At least one month is required for ripening. Laguiole or Guiole cheese is considered superior to Cantal, although the two varieties are made in essentially the same way.

LANCASHIRE.

This is an English cheese, named from the county in which it is made. The evening's milk is partly skimmed and is heated, so that when the morning's milk is added the temperature of the whole is brought to 80° F., or slightly higher. Rennet enough is added to coagulate the milk in one hour. The curd is broken up, stirred for a short time, and pressed on the bottom of the vat by means of a heavy sieve. The whey is soon drained off, and the curd is ground in a curd mill into particles the size of kernels of corn and then put into the press. Salting is done in brine, in which the cheese is placed for from four to six days. From the brine tank the cheese is transferred to the curing room.

LANGRES.

This is a soft, rennet cheese made in the northeastern part of France. It derives its name from the village of Langres in the Department of Haute-Marne, where it is said to have been made since the time of the Merovingian kings. The perfectly fresh milk is set with rennet at a temperature of about 90° or 95° F. After standing for several hours it is put into cylindrical forms. The cheeses ripen for about two or three months. A ripened cheese weighs from 1½ to 2 pounds and is about 5 inches in diameter and 8 inches high. For the most part the cheese is consumed in the region where it is made.

LAPLAND.

The Laplanders make a variety of cheese from the milk of the reindeer. It resembles very much the harder varieties of the Emmental group. The cheese has a very unusual shape, being round and flat and so formed that a cross section resembles a dumb-bell with angular instead of round ends.

LATTICINI.

This is applied to cheeses made from the milk of buffaloes, particularly in the region of Naples, but also in other parts of Italy.

LEATHER.

Leather, Leder, or Holstein Dairy Cheese, is made in Schleswig-Holstein, from cows' milk, skimmed, with an addition of from 5 to 10 per cent of buttermilk.

The milk is set at from 95° to 100° F. and requires from 25 to 35 minutes for coagulation. It is then broken up with a harp or a stirring stick and is stirred with a Danish stirrer. When the particles are reduced to the size of peas, the curd is piled up on one side of the vat or kettle and allowed to stand for 10 minutes. The whey is then dipped off. The curd is cut with a knife into pieces the size of the hand, put into a wooden or tin bowl, and pressed for one-half hour, when it is cut into pieces and run through a cheese mill. It is then salted, put into a cloth, and again put into the press, where the pressure is gradually increased. The cheese is turned occasionally and a fresh, dry cloth supplied. After 12 hours of pressing the cheese is put into the salt bath, where it is kept from 40 to 48 hours. It is then transferred to the ripening cellar, where it is wiped with a dry cloth every day for about a week and thereafter twice a week, the ripening requiring about four months. The cured cheese has small eyes; it is cylindrical, is from 4 to 6 inches in height and 10 to 12 inches in diameter, and weighs from 15 to 25 pounds.

LEICESTER.

This is a hard, rennet cheese made from whole milk of cows. It is named from a county in England where it is made. It resembles the better known Cheshire and Cheddar in every way.

Evening's milk is mixed with morning's milk and set at a temperature of from 76° to 84° F. The curd is allowed to set very firm, which requires 90 minutes. It is cut very carefully and allowed to settle 20 minutes, when the whey is drawn off. The curd is then gathered in a cloth, pressed, and broken up several times until a certain degree of dryness has been attained, when it is salted lightly and put to press. Pressure is continued for five days, the cheese being removed and salted on the outside each day.

LESCIN.

This cheese is made in the Caucasus from sheep's milk, the sheep being milked directly into a sack made of skin. Rennet is added, the curd is broken up, and the whey drained off. The curd is put into forms and pressed lightly. After coming from the press the cheese is wrapped in leaves bound with ropes of grass. After 14 days it is salted and again covered the same as before.

LEYDEN.

This is a hard, rennet cheese made in Holland, where it is known also as Bergues, Delft, Komynde, Koejekaas, and Hobbe. The milk, which is either partly or entirely skimmed, is set with rennet at from 72° to 75° F. It is allowed to stand for one hour, when the curd is cut and then stirred while being warmed to 97° F. The heating is done by pouring hot whey over the curd. The curd is then dipped out with a cloth and kneaded by hand. Caraway seed is added to a portion of the curd which, in filling the hoops, constitutes the middle of three layers. The cheese is then put into press, turned after three

hours, and a fresh cloth applied. The pressing continues for 24 hours. Salting is done on the surface daily. If the rind becomes hard it is washed in whey or water, and occasionally milk is smeared on the surface, which is colored with litmus in alkaline water. A ripened cheese weighs about 25 pounds and is 12 inches in diameter and from 3½ to 5 inches in thickness. As seen on the American market, it has a very dark-brown surface.

LIEDERKRANZ.

This cheese is manufactured at Monroe, N. Y., under a copyright. It is about 1½ inches by 2½ inches in dimensions and about an inch thick. It is ripened by red-slime growth on the surface and somewhat resembles a Limburg in flavor.

LIMBURG.

This is a soft, rennet cheese made from cows' milk which may contain all the fat or may be partly or entirely skimmed. The best Limburg is undoubtedly made from the whole milk. This cheese has a very strong and characteristic odor and taste, weighs about 2 pounds and is about 6 by 6 by 3 inches.

The most common synonyms of Limburg are Backstein and Hervé. There are, however, many local names for it, such as Algau, Lanark, Marianhof, Morin, Saint Michels, Schützen, Tanzenberg, Carinthian, Grottenhof, Emmersdorf, Briol, and Lindenhof.

Limburg cheese originated in the Province of Lüttich, Belgium, in the neighborhood of Hervé, and was marketed in Limburg, Belgium. Its manufacture has spread to Germany and Austria, where it is very popular, and to the United States, where large quantities are made, mostly in New York and Wisconsin.

Sweet milk, without any coloring matter, is set at a temperature of from 91° to 96° F. with sufficient rennet to coagulate the milk in about 40 minutes. In foreign countries a kettle is used, but in the United States an ordinary rectangular cheese vat is found to be more satisfactory. The curd is cut or broken into cubes of about one-third of an inch and is stirred for a short time without additional heating. It is then dipped into rectangular forms 28 inches long, 5½ inches broad, and about 8 inches deep. These forms are kept on a draining board, where the whey drains out freely. When the cheese has been in the forms, with frequent turnings, for a sufficient length of time to retain its shape, it is removed to the salting table, where the surface is rubbed daily with salt. When the surface of the cheese commences to get slippery the cheese is put into a ripening cellar having a temperature of about 60° F. While in the cellar the surface of each cheese is frequently rubbed thoroughly. To ripen requires one or two months. When ripe the cheese is wrapped in paper, then in tin foil, and put into boxes, each containing about 50 cheeses.

Contrary to the popular belief, no Limburg is imported into this country at the present time. This type of cheese is made so cheaply and of such good quality in this country that the foreign make has been crowded out of the market.

LIPTAU.

This cheese is made in the Provinces of Liptau, Saros, and Arva, in Hungary, from sheep's milk. Condiments, especially red peppers, are usually added. It is rather greasy and has a sharp taste. The details of manufacture are the same as those for Brinsen cheese.

LIVAROT.

This is a soft, rennet cheese made from cows' milk more or less skimmed. It derives its name from the village of Livarot, in the Department of Calvados.

France, where the industry is centralized. This cheese has the advantage over Camembert, made in the same region, in that it may be manufactured and consumed during the warm months.

The milk is set with rennet at a temperature of from 95° to 104° F. After one and one-half or two hours the curd is cut and placed on a rush mat or a cloth and allowed to drain for about 15 minutes, during which time it is crumbled as fine as possible. It is then put into tin hoops or forms 6 inches in diameter and the same in height. The cheeses are turned very frequently until they become firm, when they are salted and left on the draining board for four or five days. At this stage they are sometimes sold as white cheese, but more often they are transferred to a well-ventilated room for 15 or 20 days and then to the curing cellar, which is kept very tightly closed. By thus retaining the ammonia and other products the cheese acquires a strong, piquant taste. During the process of ripening the cheeses are turned two or three times a week and occasionally wiped with a cloth moistened with salt water. After ripening for 10 or 12 days they are wrapped with the leaves of *Typha latifolia*, in France commonly called laiche. In from three to five months they are colored with annatto and marketed.

LORRAINE.

This is a small, sour-milk hard cheese made in Lorraine, Germany, where it is regarded as a delicacy. It is seasoned with pepper, salt, and pistachio nuts and is eaten in a comparatively fresh state. The cheeses are made in sizes of about 2 ounces and sell for a very high price—at the rate of about 50 cents a pound.

LÜNEBERG.

This cheese is made in the small valleys of the Voralberg Mountains in the western part of Austria. The art of cheesemaking in that locality was introduced from Switzerland, and the copper kettle and characteristic presses are used. Saffron is used for coloring, and the milk is warmed in the kettle to 87° or 90° F., at which temperature enough rennet is added to coagulate the milk in from 20 to 30 minutes. The curd is cut into pieces the size of hazlenuts and is cooked with stirring to a temperature of 122° F. The curd is dipped into cloths which are put into wooden forms and light pressure is applied. The curd remains in the press for 24 hours, during which time it is turned occasionally and a dry cloth supplied. The cheese is then taken to the cellar, salted on the surface, and occasionally rubbed and washed. When ripe it is said to be about midway in type between Emmental and Limburg.

MACONNAIS.

This is a goats'-milk cheese, 2 inches square by 1½ inches thick, made in France.

MACQUELINE.

This is a soft, rennet cheese of the Camembert type, 4 inches in diameter and 1¼ inches thick, made from whole or partly skimmed milk in the region of Senlis, in the Department of Oise, France. The milk is set with rennet at a temperature of about 80 F. and allowed to stand for five hours, when the curd is put into hoops. After 24 hours the hoops are removed and the cheese is salted and taken to the curing room, where it remains for 20 days or more. A cheese weighs about one-fourth of a pound and requires about 2 liters of milk in its manufacture. It sells at a lower price than Camembert, made in the same region.

MAIKÄSE.

This is a cheese resembling Gouda. It is made in Holland in the early summer, is softer than the regular Gouda, and hence can be marketed at an earlier period.

MAILE.

This a rennet, sheep's-milk cheese made in the Crimea. After cooking, the curd is allowed to drain into a cloth for two hours, when it is salted, made into forms, and put into salt water, where it is sometimes kept a year.

MAILE PENER (FAT CHEESE).

This cheese is made in the Crimea from sheep's milk. The milk is set at 100° F. with sufficient rennet to coagulate in from 15 to 30 minutes. The curd is broken up, the whey dipped off, and the curd allowed to drain for from two to six hours, in a linen cloth. It is pressed with a board and salted in brine. The ripened cheese, which will keep a year, has a crumbly, open texture and an agreeable taste.

MAINZ HAND.

This is a typical hand cheese, sometimes called Pimp. The milk is treated in the usual way, and the curd after cooling is thoroughly kneaded by hand, the thoroughness of this manipulation influencing the quality of the cheese. The curd is then pressed by hand into flat cakes and allowed to dry for a week, when they are packed in a jar or keg and placed in a cellar for ripening. This requires from 6 to 8 weeks.

MALAKOFF.

This is another form of Neufchâtel cheese, about 2 inches in diameter and one-half of an inch in thickness. It may be consumed either while fresh or after ripening.

MANUR.

This cheese is made in Servia from either sheep's or cows' milk. The milk is first heated to the boiling temperature and then cooled until the fingers can be held in it. A mixture of buttermilk and fresh whey with rennet is added. The curd is lifted from the whey in a cloth and allowed to drain, when it is kneaded like bread, lightly salted, and dried.

MAQUÉE.

This is a soft, rennet, brick-shaped cheese made from cows' milk in Belgium, where it is known as Fromage Mou.

MÄRKISCH HAND.

This cheese is similar to a hand cheese, the milk being treated in the same way as in hand cheese up to the salting. The curd is then put into a linen sack and heavy pressure is applied. The mass is then cut into oblong pieces and allowed to dry and cure as regular hand cheese.

MAROLLES.

This is a soft, rennet cheese of the Point l'Évêque type made from cows' milk, whole or partly skimmed, in the Departments of Aisne and Nord, France. There are several kinds, varying in size, shape, and details of manufacture, of

which the Larron and the Tuile de Flandre are best known. The cheese as made at Maroilles is about 6 inches square and 2 inches thick; that made at Saint Aubin is 5 inches square and 3 inches thick. The Larron is about 2¼ inches square and 1½ inches thick and weighs about 6 ounces, while the Tuile de Flandre is about twice as large. The Dauphin is semilunar in shape and contains herbs. A pear-shaped form, designated Boulette, may be made in part from buttermilk.

The best cheese is made from fresh, whole milk, although the most of it is made from milk partly or entirely skimmed. The temperature of setting with rennet is about 75° F. and the time allowed from one to four hours. The curd is drained for one or two hours in a box having a perforated bottom and is then put into square forms or hoops 5 or 6 inches on a side and 3 or 4 inches high. The cheese is turned frequently until firm and then salted on all six faces and taken to the curing cellar, where it is washed frequently with salt water to prevent the growth of molds. Ripening requires from three to five months. Defective cheeses are said to be common.

MASCARPONE.

This is a cheese about 2 inches in diameter and 2½ inches in height, and made in Italy. The cream is heated to about 194° F., and dilute acetic or tartaric acid is added. The mixture is stirred and drained through cloth, then put into molds, and eaten in a fresh condition.

MECKLENBURG SKIM.

This is a rennet cheese made from skim milk and named from the province in which it is made. The milk is placed in a copper kettle and warmed with steam. Saffron is added for coloring, and sufficient rennet is used to coagulate the milk in 30 minutes. The curd is broken up into particles the size of peas. The temperature is raised to 92° F. in 12 minutes. The curd is then removed from the kettle by means of a cloth, put into a hoop, and pressure applied. This is increased gradually until it reaches 15 times the weight of the cheese in 24 hours. The cheese is then placed in a drying room held at 70° F. until a rind is formed. As much salt as can be absorbed is then sprinkled on the surface. In the meanwhile the cheese is taken from the drying room and placed in the regular curing room, which has a temperature of 60° F. and a relative humidity of from 85 to 95 per cent.

MESITRA.

This is a soft, sheeps'-milk cheese made in the Crimea. The fresh milk is set with rennet in a copper kettle. After cutting, the curd is heated over a slow fire. The curd is dipped when comparatively soft and subjected to light pressure. The cheese is often eaten fresh and unsalted.

MIGNOT.

This is a soft, rennet cheese, either cylindrical or cubical in form. It has been made in the Department of Calvados, France, for more than 100 years and resembles Pont l'Évêque and Livarot. There are two types of this cheese, white and passé; the first, a fresh cheese, is made during the period from April to September, and the second, a ripened cheese, is made during the remainder of the year.

MINTZITRA.

This is a soft cheese made of sheep's milk in Macedonia.

MONTASIO.

This cheese originated in the part of Carinthia, in Austria, called Friaul, where the value of the annual product is very large. At the present time it is made not only in Carinthia but in the neighboring Provinces and in Italy.

The milk, either whole or partly skimmed, and consisting usually of a mixture of cows' and goats' milk, is heated in a kettle to 95° F., and sufficient rennet is added to coagulate it in 30 or 40 minutes. It is then cut very carefully to the size of peas and heated gradually to a temperature of 120° F. When the desired temperature is reached, which is usually in about one-half hour, heating is stopped and the stirring continued for 30 or 40 minutes. Some of the whey is dipped from the kettle, and the curd is removed by means of a cloth. The cheese is pressed for 24 hours, during which time it is turned frequently. The salting requires usually about one month, the total quantity applied varying from 2½ to 3 per cent of the weight of the pressed cheese. After salting, the cheese is taken to a well-ventilated room and allowed to dry. In this room the cheese is turned frequently and rubbed in order to free it from molds. When dry, it is scraped carefully and taken to the curing cellar, where it is rubbed frequently with a coarse cloth, and when the rind has become firm and does not show the presence of mold, olive oil is usually applied. Sometimes the rind is blackened by means of soot.

The fresh cheese is almost white. The old cheese becomes yellow, granular, and has a sharp taste and characteristic odor. It is usually eaten when from 3 to 12 months old, but may be kept much longer and then grated.

MONTAVONER.

This is a sour-milk cheese made in Austria. During the process of manufacture dried herbs (*Achillea moschata* and *A. atrata*) are added.

MONT CENIS.

This is a hard, rennet cheese resembling the imitation Roquefort varieties like Gex and Septmoncel and made in the region of Mont Cenis, in the southeastern part of France. The milk used is usually a mixture of cows', sheep's, and goats'. The evening's milk is usually skimmed and added to that of the morning. Primitive methods of cheesemaking are employed. The milk is set with rennet at a temperature of about 85° F. The curd is then cut and allowed to drain for 24 hours, when fresh curd is thoroughly mixed with it. The mixture is then put into molds and moderate pressure applied. After turning frequently for several days, and salting, it is transferred to the curing cellar, where it is turned frequently, washed with salt water to check the growth of molds on the surface, and allowed to ripen for three or four months. The ripening is due mainly to a penicillium which is sometimes incorporated into the curd by means of moldy bread. A ripened cheese is about 18 inches in diameter, 6 or 8 inches in height, and weighs about 25 pounds.

MONT D'OR.

This is a soft, rennet cheese of the Pont l'Évêque type, formerly made from goats' milk but now made almost exclusively from cows' milk. Sometimes a small quantity of goats' milk is added to the latter.

It derives its name from Mont d'Or, near Lyon, in the Department of Rhône, France, where it is said to have been made for more than three centuries. At the present time it is made not only in Rhône and neighboring Departments, but in other parts of France, especially Eure and Oise.

Whole or partly skimmed milk is set with rennet at a temperature of 90° or 100° F. The curd, in from one-half hour to two hours after the addition of the rennet in the milk and with or without cutting, is put into circular forms or hoops about 4½ inches in diameter and 3 inches high, which rest upon a draining board covered with straw. After about one hour the cheese is turned, and frequently thereafter, until firm. A disk with a light weight is sometimes placed upon each cheese in order to hasten the removal of the whey. The cheese is salted on the surface. It is also ripened for about one week in summer and two or three weeks in winter, during which time it is turned frequently and washed with salt water to prevent the growth of molds. Much of it is sold in a fresh condition.

MONTLHÉRY.

This is a soft, rennet cheese made from cows' milk in Seine-et-Oise, France. A large cheese is about 2 inches thick and 14 inches in diameter and weighs about 5½ pounds. There is also a smaller-sized cheese which weighs about 3 pounds. Either whole milk or partly skimmed milk is used. Rennet is added to it at ordinary temperatures, and the curd when sufficiently firm is broken up, put into molds, and subjected to pressure. After salting, the cheese is cured for from 8 to 15 days in a so-called drying room and then ripened in a cellar at a temperature of about 55° F. During the process of ripening the cheese becomes covered at first with a whitish mold and later with a blue mold in which red spots appear. After about one month it is ready for sale.

MOZARINELLI.

This is a soft, rennet cheese made in Italy from cows' milk.

MÜNSTER.

Münster is a rennet cheese of cows' milk unskimmed, made in the vicinity of Münster, in the western part of Germany near the Vosges Mountains. Similar cheese made in the neighboring portion of France is called Géromé, and Münster cheese made near Colmar and Strassburg is sometimes given the names of those two cities.

The milk is set at about 90° F. with sufficient rennet to coagulate it in 30 minutes. The curd is then broken up and allowed to stand from 30 to 45 minutes without stirring, when it is dipped with a sieve, which gives slight pressure to the curd and holds back the small particles. After removing the whey the curd is scooped into forms or hoops, and caraway or anise seed is usually added. The hoops are made in two parts, the lower being 4 inches high and 7 inches in diameter, with holes in the bottom for draining, and the upper of the same dimensions. The whole resembles an ordinary cheese hoop with bandages. The hoop is lined with cheesecloth. After the curd has been in the hoop for 12 hours the upper part of the latter may be removed, the cheese turned, and the cloth removed. The cheese is now put into the upper portion of the hoop and turned frequently for from four to six days. In the meanwhile the temperature is held at 68° F. After salt has been rubbed on the surface daily for three days the cheese is taken to the cellar, which has a temperature of from 51° to 55° F., where it is allowed to ripen for two or three months. When ripe the cheese sells for about 15 cents a pound.

MYSOST.

Mysost is made from whey, is a product of Norway, Sweden, and Denmark, and, to a very limited extent, of the United States. It has a light-brown color, a buttery consistency, and a mild, sweetish taste.

The method of manufacture is as follows: As soon as the curd of the regular cheese is removed from the whey the latter is strained and put into a kettle or large pan over the fire, and the albuminous material which rises to the surface is skimmed off. The whey is evaporated as rapidly as possible with constant and thorough stirring. When it has reached about one-fourth its original volume the albumin previously skimmed off is returned and stirred thoroughly to break up all possible lumps. When the whey has attained the consistency of thickened milk it is poured quickly into a wooden trough and stirred with a paddle until cool, to prevent the formation of sugar crystals. It can then be molded into the desired form. In this country it is usually made into cylindrical shapes and wrapped in tin foil. Primost is a local name for this cheese.

NAGELKAZEN.

This is the trade name of a species of cheese mentioned by John Ashton in an article on cooperative creameries in Holland. The cheese is made of new curd with cloves mixed in.

NESSEL.

This is a soft-cured, rennet cheese made from cows' milk, unskimmed. It is an English product and is round and very thin.

NEUFCHÂTEL.

This is a soft, rennet cheese made extensively in the Department of Seine Inférieure, France, from cows' milk either whole or skimmed. Bondon, Malakoff, Petit Carré, and Petit Suisse are essentially the same as Neufchâtel, but have slightly different shapes.

Neufchâtel cheese is made in identically the same manner as Cream cheese, with the exception that a little less rennet is used, perhaps 1 ounce of commercial liquid rennet to 1,000 pounds of milk. This product is made from whole milk or milk partially skimmed. The standard package, wrapped in tin foil, is round and weighs $2\frac{1}{2}$ or 3 ounces, its dimensions being $1\frac{1}{2}$ by $2\frac{1}{2}$ inches. Factories in the United States make a variation of the Neufchâtel cheese, which is very probably as good as the French variety. Makers in this country attempted to vary this cheese by the use of condiments. Pimiento, or Pepper Cream, is a Neufchâtel cheese in which 1 pound of red peppers is used for every 10 pounds of cheese. The peppers are ground very fine and thoroughly mixed with the cheese; the whole is then molded into forms and kept in a cold place.

NEW MILK.

This cheese is made in Holland, the process of manufacture resembling that of Gouda cheese. It is made only in limited quantities at the beginning of the summer season, and is eaten fresh.

NIEHEIM.

This is a sour-milk cheese made in Westphalia and named from a city in that Province. The sour milk is heated to a temperature of 100° or 120° F. The curd is collected in a cloth and allowed to stand for 24 hours, when it is worked until in a fine condition. It is then made up into cakes, which are put into a cellar and turned frequently for from five to eight days, when it is broken

up, and salt and caraway seed, and sometimes beer or milk, are added. The cheese is covered lightly with straw and finally packed in casks with hops and allowed to ripen.

NOSTRALE.

This name is applied locally to two kinds of rennet cheese made from cows' milk in the mountainous regions of northwestern Italy. The hard cheese, designated Formaggio Duro, is made during the spring, while the herds are still in the valleys, and the soft cheese, Formaggio Tenero, during the summer, when they are pastured in the mountains. The cheese is said to be a very old variety and the methods of manufacture to have remained primitive. A cheese designated Raschera, made in the region of Mondovi, is probably the same as Nostrale.

OLIVE CREAM.

This cheese is made by mixing ground olives with cream cheese to suit the taste of the customer. Some manufacturers put it on the market already prepared.

OLIVET.

This is a soft, rennet cheese made from cows' milk. The manufacture of this variety originated south of Orleans, in the Department of Loiret, France. The industry is now carried on north of Orleans near Olivet, to which place the cheese doubtless owes its name. It has three forms, designated white or summer cheese, blue or the ordinary half-ripened form, and ripened. In general the process of manufacture resembles that of Camembert. The ordinary form is made from either whole milk or partly skimmed milk. About two hours after the addition of rennet the curd is placed in a receptacle having holes in the bottom and sides and allowed to drain for 24 hours, when it is put into forms about 6 inches in diameter. The cheese is turned and salted the next day, and about one day later is taken to the first curing room, where it is placed on shelves covered with straw. This room is kept at a temperature of about 65° F. and the cheese becomes red in a few days and later blue. The blue color is a sign of maturity, and its appearance requires from 10 to 15 days in summer and one month in winter. The cheese is then ready for marketing. When properly cared for it may remain in good condition for several months. The form designated ripened is made in the same way until the blue color appears, when the cheese is put into the curing cellar, where ripening is carried to a much greater extent. Ordinarily it requires from 15 to 30 days, but sometimes the cheese is covered with ashes, which are believed to hasten the ripening process. The form designated white or summer cheese is made from whole milk, to which cream is sometimes added. The curd is obtained in the ordinary manner and pressed into molds, in which it is sold as fresh cheese, summer cheese, white cheese, or cream cheese.

OLMÜTZER QUARGEL.

This is a hand cheese made extensively in the western part of Austria. It is 1½ inches in diameter and one-third of an inch thick and contains caraway seed. It is made with 5 per cent of salt and after drying is put into salt whey for a time. It is then packed in kegs and ripened for 8 or 10 weeks. In all other respects the manufacture is identical with that of Hand cheese.

OSSETIN.

This cheese is made in the Caucasus from sheep's or cows' milk, the best being made from the former. The fresh, warm milk is set with rennet in sufficient quantity to coagulate quickly. The curd is broken up with the hand

and is cooked until it has the proper degree of firmness, after which it is kneaded together and the whey removed. It is then put into round forms, sprinkled with salt, and allowed to remain for two days. The cheese then goes into brine, where it may be kept for a year, or even longer. A softer, milder cheese is produced by leaving it in the brine for two months.

Tuschinsk and Kasach are other names for Ossetin.

OSTIEPEK.

This is a sheep's-milk cheese made in the Carpathian Mountains. The process is said to be the same as that used by the Italians in making the better known Caciocavallo.

OVCJI SIR.

This is a sheep's-milk cheese made in the Slovenian Alps. Morning's milk is mixed with evening's milk in a kettle holding about 50 liters and warmed to from 86° to 95° F. over an open fire. A sufficient quantity of rennet made from a kid's stomach is added to coagulate it in about 30 minutes. The curd is broken up and heated to 122° F., drained for an hour in a rack, and placed on a wooden vessel or hoop. Salt is rubbed on the surface of the cheese each day for a week. The cheese is ripened for three months in a cellar, and when ready for sale weighs from 6 to 10 pounds.

PAGLIA.

This is a more or less successful imitation of Gorgonzola cheese, made in the Canton of Ticino, Switzerland. A cheese is 8 inches in diameter and 2 inches in thickness. The milk is set at a temperature of 100° F., the time allowed being about 15 minutes. The curd is broken up, stirred, and put into hoops. When sufficiently drained the cheese is taken to a cool cellar and placed on straw, where fermentation is usually very rapid and marked. The process is delayed to some extent by excessive salting, which is continued for about a month. The cheese is very soft in consistency and has a pleasant, aromatic flavor.

PAGO.

This is a rennet cheese made from sheep's milk in the island of Pago, in the Province of Dalmatia, Austria. It is put up in sizes weighing from one-half to 8 pounds.

PARENCIA.

This is a sheep's-milk cheese made in Hungary. The process is similar to that used in making Caciocavallo.

PARMESAN.

Outside of Italy this name is in common use for the cheese made and known in that country for centuries as Grana, the term "grana" or "granona" referring to its granular appearance when broken, which is necessary on account of the hardness of the cheese, cutting being practically impossible. There are two quite distinct kinds of this cheese—one made in Lombardy and the other in Emilia, the centers of production being separated by the River Po. Parma, situated in Emilia, has long been an important commercial center for both kinds, and to this fact the name Parmesan is due. The use of the term "Parmesan," however, is sometimes restricted to the cheese made in Lombardy, the term "Reggian" being used to designate that made in Emilia. Italian

writers refer usually to the Lombardy cheese as Cacio or Formaggio Grana Lodigiano, Lodi being an important center of trade, and to the Emilian cheese as Grana Parmigiano or Reggiano. The Lodi cheese is larger and made from a poorer quality of milk than the Reggian, which is colored and brings a much higher price. The following description of the process of manufacture applies to both kinds:

The milk, which has been skimmed to a greater or less extent, is heated in copper kettles to a temperature varying, according to the acidity of the milk, from 90° to 100° F. The kettle is then removed from the fire, rennet added, and the kettle covered and allowed to stand for 20 minutes to one hour, when the curd is cut very fine and cooked, with stirring, to 115° or 125° F. for from 15 to 45 minutes. The curd is removed from the kettle by means of a cloth, and after draining for a short time is put into hoops about 10 inches high and 18 inches or more in diameter, and lined with coarse cloth before filling. Pressure is then applied for 24 hours, the cheese being turned frequently and the cloths changed. The salting, which is begun in from one to three days after removing from the press, is continued for a considerable length of time, often 40 days. The cheeses are then transferred to a cool, well-ventilated room, where they may be stored for years, the surface being rubbed with oil from time to time. The exterior of the cheese is dark green or black, due to coloring matter rubbed on the surface. A greenish color in the interior has been attributed to the contamination with copper from the vessels in which the milk is allowed to stand before skimming.

The Lombardy cheese made from April to September is known locally as Sorte Maggenga and that from October to March as Sorte Vermenga. The Reggian cheese is made only in summer.

Parmesan cheese when well made may be broken and grated easily and may be kept for an indefinite number of years. It is grated and used largely for soups and with macaroni. A considerable quantity of this cheese is imported into this country and sells for a very high price.

PECORINO.

The Formaggi Pecorini are the sheep's-milk cheeses made in Italy and of which there are numerous more or less clearly defined kinds. The most common cheese of this sort is the one designated Cacio Pecorino Romano, or merely Romano. This varies considerably in size and shape. A cheese of ordinary size is about 10 inches in diameter and 6 inches in thickness and weighs from 2 to 25 pounds. The interior is slightly greenish in color, somewhat granular, and devoid of eyes or holes. In making Romano cheese the milk is heated to 100° F. and coagulated by rennet in 15 minutes. The curd is cut, cooked to 120° F., stirred, put into forms, and allowed to drain. Salting is done both by immersion in brine and by rubbing salt on the surface. As much as 7 or 8 per cent of salt is usually incorporated in the course of one month. This process is sometimes facilitated by punching several holes in the cheese. Ripening is usually done at a temperature of 60° or 70° F. and requires eight months or longer.

The Pecorino Dolce is artificially colored with annatto and subjected to considerable pressure in the process of manufacture.

Pecorino Tuscano is a smaller cheese than the Romano, measuring usually 6 inches in diameter and 2 or 4 inches in thickness and weighing from 2 to 5 pounds.

Among the sheep's-milk cheeses bearing local names are the following: Ancona, Cotrone, Iglesias, Leonessa, Puglia, and Viterbo. In the manufacture of

Viterbo cheese the milk is curdled by means of a wild artichoke, *Cynara scolymus*.

PECORINO SARDO.

This is a rennet, sheep's-milk cheese, made in Sardinia. A rennet made by soaking calves' stomachs a day in salt water is added to the freshly drawn milk, the temperature for adding the rennet being determined by the hand. The coagulated milk is allowed to stand until clear whey shows around the edges of the kettle, when the curd is broken up and put into molds under light pressure until the whey stops running. The cheese is salted in brine for a day and is then placed in the curing room.

PENTELEU.

This cheese is made in Roumania, from sheep's milk, after the general process used in making Caciocavallo.

PFISTER.

This cheese is classed in the Emmental group, though its method of manufacture differs materially. It is made from fresh skimmed milk of cows. It takes its name from Pfister Huber, in Cham, Switzerland, who evidently was the first to manufacture it.

The milk is set at 85° F. with sufficient rennet to coagulate it in 30 minutes. The curd is cut coarse and allowed to stand for 15 minutes, when the whey is dipped off. The curd is again stirred for five minutes, care being taken that the temperature does not fall below the setting point. The curd is again allowed to stand for five minutes, when it is taken from the kettle in a cloth and put in a hoop, where it is pressed for 24 hours, being turned occasionally and dry cloths substituted. The cheese is transferred from the press to the salt bath, where it remains for three days. It is then taken to a moist room having a temperature of 85° F., where it is placed on shelves and turned and occasionally salted. The cheese is ready for market at about 6 weeks of age. It is drum-shaped, like a characteristic Emmental, but not so large, weighing about 50 pounds.

PHILADELPHIA CREAM.

This is an ordinary cream cheese, put up by a firm in the State of New York. It is 3 by $2\frac{1}{2}$ by $1\frac{1}{4}$ inches in size and is wrapped in parchment paper and tin foil.

PIMIENTO.

Pimiento cheese is any kind of cheese to which pimiento or Spanish peppers have been added, the most common type being Neufchâtel or cream; they are sometimes added to Club cheese or Cottage cheese and occasionally to hard Cheddar cheese.

PINEAPPLE.

This cheese, which is said to have had its origin in Litchfield County, Conn., about 1845, is so named from the fruit whose shape the cheese is made to resemble. It is a hard, rennet cheese made from cows' milk, whole. The cheese is quite hard and rather highly colored. The early process of manufacture is the same as Cheddar, except that it is cooked much harder. The curd is pressed into the desired shape in various sizes up to 6 pounds in weight. After pressing, the cheese is dipped for a few minutes in water at 120° F. and is then put into a net for 24 hours, which gives it the diamond-shaped corrugations on the surface. It requires several months to ripen, during which time the surface is rubbed with oil, making it very smooth and hard.

PONT L'ÉVÊQUE.

This is a soft, rennet cheese made from cows' milk. Three grades are recognized, depending upon the quality of the milk used. A Pont l'Évêque cheese is about 4½ inches square and 1¼ inches thick.

This cheese was made in the thirteenth century in the valley of Auge, from which it derived its earlier name, Augelot, and by corruption Angelot. The principal seat of the industry at the present time is Pont l'Évêque and vicinity, in the Department of Calvados, France. The manufacture of this cheese is of considerable importance in the region named. The milk used may be either whole milk with or without the addition of cream, a mixture of whole and skimmed milk, or milk entirely skimmed.

Coloring matter and warm or hot water are usually added to the milk before setting with rennet, which is done at a temperature of about 95° F. After standing for from 15 to 30 minutes the curd is cut, removed to a draining board for a few minutes, and then put into square forms or hoops. The cheese is turned very frequently during the first half hour and five or six times more during the remainder of the first day. It is salted the second or third day and transferred to a well-ventilated room for several days. When sufficiently dried it is taken to the curing cellar. During drying and ripening the cheeses are turned every day and while in the cellar are washed frequently with salt water. Ripening requires usually from 3 to 6 weeks.

PORT DU SALUT.

This is a rennet cheese made from cows' milk. In many respects it is intermediate between the soft and hard varieties. The rind is firm and resistant but the interior is soft and homogeneous, though it does not become semiliquid like the interior of Brie cheese. This variety of cheese originated about 1865 in the Trappist Abbey, Port du Salut, about 6 miles from Laval, in the Department of Mayenne, France. While to some extent the process is kept a secret by the Trappists, very successful imitations are made outside the monasteries in that region.

The milk, either whole or partly skimmed and preferably slightly acid, is heated to 90° or 95° F. and sufficient rennet added in order to obtain the desired firmness of the curd in about 30 minutes. Coloring matter is usually added to the milk. The curd is cut very fine and in a manner similar to that followed in making Emmental cheese. This requires about 20 minutes, after which part of the whey may be removed. The curd is then stirred and may be heated or cooked to a moderate degree. The final temperature reached in cooking varies from 100° to 105° F., depending upon the acidity of the milk. The time required in stirring and heating is about 20 minutes. The curd is then allowed to settle and the whey removed. After being stirred vigorously for from 2 to 4 minutes, the curd is put into molds which are of two sizes, the smaller about 7 inches in diameter and the larger about 10 inches. A disk is placed on the cheese and pressure applied by means of presses for from 10 to 12 hours, the cheese being turned and the cloths frequently changed during that time. The next day the hoops are removed and the cheese salted. After drying for about 24 hours it is transferred to the ripening cellar, where it remains from 5 to 6 weeks. In this place a temperature of about 55° F. and a relative humidity of 85° or 90° F. is preferred. During ripening the cheeses are turned very frequently and washed with salt water, the frequency depending somewhat upon the rapidity with which molds develop. The cheese is often sold before the ripening process is entirely complete.

POTATO.

This cheese is made in Thuringia, in the central part of Germany. In the manufacture of potato cheese, curd is made from cows' milk, sour, or in some cases from renneted milk. Sometimes sheep's or goats' milk is used. The potatoes are boiled and grated or mashed. One part of the potatoes is thoroughly mixed or kneaded with two or three parts of the curd. In the better cheese three parts of potatoes are mixed with two of curd. During the mixing salt and sometimes caraway seed is added. The cheese is allowed to stand for from two to four days while a fermentation takes place. After this the curd is again thoroughly kneaded and placed in forms for a day. It is then dried and is sometimes covered with beer or cream, and is finally placed in tubs and allowed to ripen for 14 days.

A variety of this cheese is made in the United States. It is probable, however, that it is not allowed to ripen for quite so long a period as the potato cheese of Europe. In all other essentials it appears to be identically the same.

POTTED.

This cheese very probably originated in the United States. It is usually prepared from well-ripened Cheddar cheese by grinding it very fine and mixing with butter, condiments, spirits, etc. In the past it has been put up in small porcelain jars, but at the present time a portion of it is wrapped in waxed paper and either tin or lead foil, and often goes by the name of Club cheese.

PRATTIGAU.

This is made from cows' milk, skimmed, and is so named from the valley of Switzerland in which it is made. Its manufacture is the same as that of Limburg. Cheeses weigh from 20 to 25 pounds each.

PRESTOST.

Prestost is a product of Sweden, where it is often called Saaland Pfarr. It is a rennet cheese made from cows' milk, fresh, and resembles Gouda. It was known in the eighteenth century. The milk is set at 90° F. and is allowed to become very firm, when it is cut coarse with a wooden knife and poured into a sieve, which allows the whey to drain off. The curd is then put into a cloth and kneaded. Whisky is mixed with the curd, which is then packed in a basket, and after some salt is sprinkled on the surface it is put into a cellar. The cloth inclosing the cheese is changed daily for three days, after which the cheese is washed with whisky. A cheese is cylindrical in shape and weighs from 5 to 30 pounds.

PROVIDENCE.

This cheese is about 8 inches in diameter and 1½ inches thick, and very closely resembles Port du Salut. It is made in the monastery of Bricquebec in the Department of Manche, France.

PROVOLE.

This is one of the most esteemed of the several kinds of hard, rennet cheese made from cows' milk, including also that of buffaloes, in central and southern Italy. The cheese is round or oval and weighs from 4 to 6 pounds. Smaller sizes weighing about 2 pounds are known as Provoloni. In many respects, including the cooking of the curd with hot water and the smoking of the cheese, Provole and Provoloni resemble Caciocavallo. Considerable quantities of this cheese are imported into the United States.

PULTOST.

Pultost, also called Knaost, is made usually from sour milk, but it may be made with rennet. It is a Norwegian product and is made in private dairies in the mountains of that country. The milk is placed in a kettle and, if not sour enough to coagulate on warming, the acidity is increased by the addition of buttermilk. When sufficient acid has developed, the milk is warmed to 113° F. The curd is broken up with a scoop and stirred to keep it from matting together while it is being heated to 140° F. It is then dipped and ground up fine. Buttermilk is added and the whole is thoroughly kneaded and put into troughs, where it is covered with a cloth. It is allowed to stand for three days with occasional stirring.

QUACHEQ.

This is a sheep's-milk cheese made in Macedonia. Some fermented material is added to the milk to precipitate the casein. The cheese is pressed to remove the whey. It is eaten both fresh and ripened.

QUESO DE CINCHO.

This is a sour-milk cheese made in Venezuela and known also as Queso de Palma Metida. It is exported in the form of balls from 8 to 16 inches in diameter and wrapped in palm leaves.

QUESO DE HOJA.

This a Porto Rican cheese made from cows' milk, fresh. The curd is cut into blocks about 6 inches square and 2 inches thick. After part of the whey is drained off, which may require several hours, the pieces of curd are immersed in water or whey having a temperature of 150° F. This gives a tough layer to the block of curd, which is then removed to a table and pressed or stretched by the use of a broad wooden spoon or paddle. Salt is sprinkled on the surface, and the piece of curd is folded and wrapped in a cloth and squeezed to force out the moisture. The finished product is about 6 inches in diameter, 1 or 2 inches thick, and has slightly rounded top and bottom surfaces. When the cheese is cut it appears to be in layers like leaves one upon another; hence the name, signifying leaf cheese.

QUESO DE MANO.

This is a sour-milk cheese resembling a Hand cheese and is made in Venezuela. It is from 6 to 7 inches in diameter.

QUESO DE PRENSA.

This is a Porto Rican product and is a hard, rennet cheese made from cows' milk, unskimmed. The name signifies pressed cheese. The milk is allowed to stand six hours without cooling, and rennet is then added. The curd is broken by hand or with a stick, and after part of the whey is separated the curd is transferred to a table and is broken into small pieces. It is then put into wooden frames, and salt is added either as the curd goes into the frame or by sprinkling on top. Light pressure is applied either by hand or by means of a screw. After leaving the press, the cheese is placed on racks. It may be eaten fresh or allowed to stand for from 2 to 3 months. The cheese is 11 inches long, 5½ inches wide, 3 inches thick, and weighs about 5 pounds.

QUESO DE PUNA.

This is a Porto Rican product, resembling very much the Cottage or Dutch cheese of the United States. The milk is set with rennet, and the curd is thoroughly mashed or kneaded by hand, salt being added at the same time. The curd is put into a hoop 5 inches in diameter and 1¼ inches deep, where it remains without pressure for two or three days, or until it will keep its form. The cheese is eaten fresh.

RABACAL.

This is a round, rather firm cheese made from the milk of sheep or goats in the vicinity of Coimbra, Portugal. A cheese is 4 or 5 inches in diameter and 1 inch thick.

RADEN.

This is a hard, rennet cheese made from skim milk in Mecklenburg. The cheese is 16 inches in diameter and 4 inches thick, and weighs 32 pounds. The process of manufacture does not differ materially from that of Emmental.

RANGIPORT.

This cheese is in every way analogous to Port du Salut. It is about 6 inches in diameter and 2½ inches thick, weighs about 2½ pounds, and is made in the Department of Seine-et-Oise, France.

RAYON.

This is a special type of Emmental cheese, made largely in the Canton of Fribourg, Switzerland, for exportation to Italy, though some is now manufactured in Italy. It is made of partly skimmed milk, and the cooking is continued to a point that insures a very dry, hard cheese, which develops no eyes. After curing it is shipped largely to Turin, where it is placed on edge on shelves in dry, warm caves, and the fat leaks out, leaving the cheese exceedingly dry and hard, when it is used for grating. After the drying process the cheese is called Raper.

REBBIOLA.

Rebbiola, or Robiola, is a soft cheese, made principally in the Alpine districts of Italy. The process of manufacture is very simple. It is generally made from milk skimmed after 12 hours, but whole milk is sometimes used. The cheese is circular and weighs about 2 pounds. The ripening process is very rapid, requiring usually from 12 to 15 days. The milk is set at a temperature of 90° F., the time allowed being usually about one-half hour. The curd is cut fine and put into molds 8 inches in diameter and 6 inches high, the bottom being perforated. Five hours later the cheeses are removed from the molds and placed on a draining board covered with straw. After two or three days they are salted and then ripened.

REBLOCHON.

This is a soft, French cheese, weighing 1 or 2 pounds. It is made from fresh whole milk, which is curdled with rennet at a temperature of 80° F. or above, the time allowed being about 30 minutes. The curd is cut to the size of peas, cooked to about 95° F., and after the removal of the whey is put into molds about 6 inches in diameter and 2 inches in height. A weight of about 5 pounds is

placed upon each cheese, which is turned frequently and salted after about 12 hours. In a moist room having a temperature of about 60° F. the desired degree of ripening is obtained in four or five weeks. An imitation of this cheese, made in Savoy, France, is known as Brizecon.

REINDEER MILK.

In Norway and Sweden the milk of the reindeer is sometimes used for cheesemaking. Rennet is added at 100° F., and the curd is cut and dipped into a large frame, where it is pressed lightly. The mass of curd is then cut into pieces 5 by 4 by 2½ inches, which are salted on the surface and are allowed to ripen in a dry curing room.

RIESENGEBIRGE.

This is a soft, rennet cheese, made from goats' milk in the mountains on the northern border of Bohemia. The milk is set at about 90° F. The curd is broken up and the whey dipped off, after which the curd is put into forms, where it remains in a warm place for 24 hours. It is then covered with salt and after drying for three or four days is placed in the curing cellar. From each 100 pounds of milk 18 pounds of cheese is produced.

RINNEN.

This is a sour-milk cheese which was known in the eighteenth century. It is made in Pomerania from milk sufficiently acid to cause a precipitation of the curd when it is warmed to about 90° F. The cheese derives its name from the wooden trough in which it is laid to drain. The curd is broken up, heated to expel the whey, and is kneaded by hand. Caraway seed is added, the curd is molded into forms and pressed, and salt is rubbed on the outside. The cheese is dried and put into a box to ripen.

RIOLA.

This cheese usually is made from sheep's or goats' milk. In manufacture it resembles Mont d'Or cheese, but is ripened longer, from two to three months being required. It is soft in texture and has a strong flavor.

ROCAMADOUR.

This is a sheep's-milk cheese made in the southern part of France. Rennet is added at about 77° F. and when it is sufficiently coagulated it is dipped into terra-cotta forms, where it is allowed to drain. Salt is sifted into the forms, where the cheese remains for a day. A cheese of this kind weighs about one-eighth of a pound.

ROLL.

This is a hard, rennet cheese, made in England from cows' milk, unskimmed. It is cylindrical in shape, 8 inches high by 9 inches in diameter and weighs 20 pounds.

ROLLOT.

This is a soft, rennet cheese, 2½ inches in diameter and 2 inches thick, made in the Departments of Somme and Oise, France.

ROMADOUR.

Romadour, Remoudou, or Romatur cheese is a southern Bavarian product similar to Limburg. It is 4½ by 2 by 2 inches in size and weighs 1 pound. It

is said to be a little finer variety of cheese than Limburg and to sell for a slightly higher price.

ROQUEFORT.

This is a soft, rennet cheese made from the milk of sheep. There are, however, numerous imitations, such as Gex and Septmoncel, made from cows' milk, which resemble Roquefort. One of the most striking characteristics of this cheese is the mottled or marbled appearance of the interior, due to the development of a penicillium, which is the principal ripening agent. The manufacture of Roquefort cheese has been carried on in the southeastern part of France for at least two centuries. The industry is particularly important in the Department of Aveyron, in the village of Roquefort, from which the cheese derives its name. It is also made in Corsica. Imitations of Roquefort are made in various countries.

The evening's milk is heated to 140° or 150° F., cooled, and kept overnight. After being skimmed it is mixed with the fresh morning's milk. The mixture is then set with rennet at a temperature of from 78° to 82° F. In from one to two hours after the addition of rennet the curd is cut until the particles are about the size of walnuts. The whey which rises to the surface is dipped off, and the curd is put into hoops which are about 8½ inches in diameter and 3½ inches in height. The hoops usually are filled in three layers, a layer of moldy bread crumbs being interspersed between the first and second and second and third layers. The bread used for this purpose is prepared from wheat and barley flour, with the addition of whey and a little vinegar. It is thoroughly baked and kept in a moist place from four to six weeks, during which time it becomes permeated with a growth of the mold referred to. The crust is removed, and the interior is crumbled very fine and sifted. The cheese is not subjected to pressure. It is turned usually one hour after putting into hoops and is not wrapped in cloths.

Formerly the manufacture of the cheese up to this stage was carried on by the shepherds themselves, but in recent years centralized factories have been established, and much of the milk is collected and there made into cheese. The cheese is then taken to the caves. These are for the most part natural caverns which exist in large numbers in the region of Roquefort. The temperature in these caves is 40° to 45° F., and the air circulates very freely through them. Recently artificial caves have been constructed and used. When the cheeses reach the caves they are salted, which serves to check the growth of the mold on the surface. One or two days later they are rubbed vigorously with a cloth and are afterward subjected to thorough scraping with knives, a process formerly done by hand, but now much more satisfactorily and economically by machinery. The salting, scraping, or brushing seems to check the development of mold on the surface. In order to favor the growth of mold in the interior, the cheese is pierced by machinery with from 20 to 60 small needles, which process permits the free access of air. The cheese may be sold after from 30 to 40 days or may remain in the caves as long as five months, depending upon the degree of ripening desired. During the process of ripening by scraping and evaporation the cheese loses from 16 to 20 per cent of the original weight. When ripened, it weighs 4½ or 5 pounds.

SAANEN.

This is a type of Emmental cheese made in Switzerland from cows' milk. It is sometimes known as Hartkäse, Reibkäse, and Walliskäse. First mentioned in the sixteenth century, it is still manufactured extensively at the present

time and exported to a limited extent. It sells for a higher price than the regular Emmental. The process of manufacture is identical with that of Emmental, except that it is cooked much dryer, takes much longer to cure, and keeps longer. The cheese weighs from 10 to 20 pounds, and the eyes are few and small.

The ripening period is never less than three years and many require as long as nine years, the average being six years. The cheeses are kept to great ages, it being the custom to make a cheese at the birth of a child and eat it at the burial feast or even at the burial feast of a son of the child for whom it is made. One cheese is mentioned as being 200 years old and is considered a great honor to the household. Many cheeses are kept until they are 30 years old.

SAGE.

This cheese is made by the ordinary Cheddar process and may be of any of the various shapes and sizes in which that cheese is pressed. When cut, it has a green, mottled appearance.

Formerly sage cheese was made by mixing green sage leaves with the curd before it was pressed. At the present time the flavor of sage is obtained by sage extract. To produce the green mottles, succulent green corn is cut fine and the juice is pressed out. A small portion of the milk is mixed with this juice and is set with rennet in a small vat, while the bulk of the milk is set in the ordinary manner. After the curd is cut and is firm enough to be handled, the green curd from the small vat is mixed with the uncolored curd, and the process is continued as in the Cheddar process. With many consumers this is a very popular variety of cheese.

SAINT BENOÎT.

This is a soft, rennet cheese resembling Olivet, and is made in the Department of Loiret, France. Charcoal is added to the salt which is applied to the exterior of the cheese. Ripening requires from 12 to 15 days in summer, and 18 to 20 in winter. A cheese of this kind is about 6 inches in diameter.

SAINT CLAUDE.

This is a small, square, goats'-milk cheese made in the region of Saint Claude, France. The milk is curdled with rennet and the curd placed in molds for six or eight hours. It is then salted and allowed to ripen, or may, however, be eaten when fresh. A cheese weighs from one-quarter to one-half pound.

SAINT MARCELLIN.

This is a goats'-milk cheese made in the Department of Isère, France. Sheep's milk or even cows' milk may be mixed with the goats' milk. A cheese is about 3 inches in diameter, three-fourths of an inch thick, and weighs about one-fourth pound.

SAINT REMY.

This is a soft, rennet cheese differing but little from Pont l'Évêque. It is made in the Department of Haute-Saône, France.

SALAMANA.

This is a soft, sheep's-milk cheese made in southern Europe. It is filled into bladders and allowed to ripen, when it has a very pronounced flavor. It is eaten by spreading on bread or is mixed with corn meal and cooked.

SALOIO.

This is a kind of hand cheese made from cows' milk, skimmed, on farms in the region of Lisbon, Portugal. It has the form of a short cylinder, measures 1½ or 2 inches in diameter, and weighs about 4 ounces. A similar cheese of about the same character is made in Thomar, about 50 miles north of Lisbon.

SANDWICH NUT.

This cheese is made by mixing chopped nuts with cream or uncured Neufchâtel cheese.

SAPSAGO.

This cheese is made from sour, skimmed milk of cows, principally in Glarus, Switzerland. It is known also as Schabzieger, Glarnerkäse, Grünerkäse, and Kräuterkäse. It is claimed to have been made in the thirteenth century; the authentic history at least dates back to the fifteenth century. Sapsago is a small, hard, green cheese flavored with the leaves of a species of clover; it is shaped like a truncated cone, 4 inches high, 3 inches in diameter at the base, and 2 inches at the top. This cheese is imported to some extent into the United States under the name of Sap Sago.

The skimmed milk from which this cheese is made is not allowed to become sour enough to coagulate on heating, as it would make too hard a curd. The milk, when it has reached the right acidity, is heated to the boiling temperature while being stirred. Cold buttermilk is then added, as is also some whey having a high percentage of acidity. The material coagulating on the surface is skimmed off. The milk is then stirred, while sufficient acid whey is added to precipitate the casein. When too little whey is used the curd is too soft, and when too much is used it is too hard. The curd is dipped with a skimmer and spread out to cool and then put into boxes and allowed to drain and ferment. The box is kept at a temperature of about 60° F., and pressure is applied by weighting with stones. Ripening is allowed to continue from three to six weeks. If the temperature of the room is too high, or there is not sufficient pressure, too rapid and strong fermentation results. This curd is used for making the finished product, but the cheese is seldom finished where the curd is made. The curd is ground in a mill, and every 100 pounds of cheese contains 5 pounds of salt and 25 pounds of dried *Melilotus cærulea*, an aromatic clover which is grown in the Canton of Schweiz for the purpose. The ground material is worked up into a dough and is forced into molds lined with linen cloth, and the name of the manufacturer is stamped on the large end. The mold is then emptied and refilled. The cheeses are dumped promiscuously into a large cask holding about 200 pounds. A comparatively small quantity is shipped into this country. It sells at a low price and is usually grated.

SASSENAGE.

This is a hard, rennet cheese, about 12 inches in diameter and 3 inches in thickness, made from cows' milk to which small quantities of goats' and sheep's milk are usually added. The cheese is almost identical with that of Gex and Septmoncel. It derives its name from the village of Sassenage, near Grenoble, in the Department of Isère, France. The milk used is usually a mixture of skimmed milk and whole milk. It is set with rennet, and the curd is cut and put into molds in the same manner as with the other varieties mentioned. The same is also true of the ripening process, which requires about two months.

SCANNO.

This is a sheeps'-milk cheese, made in the Abruzzi, Italy. The milk is set with rennet and the process carelessly conducted until the curd is dipped from the whey. After dipping, the curd is washed in salt water and then in hot water, after which it is collected in a linen cloth and dipped in a one-fourth of 1 per cent solution of oxid of iron in sulphuric acid, with a portion of the rust or oxid undissolved. The curd remains in this bath for 24 hours, with frequent turning. It is then put into a clean, dry room with beechwood walls and is occasionally dipped in a weak solution of iron rust and acid. The outside of the curd cheese is black, with a deep-yellow interior. The cheese has a buttery consistency, a burnt taste, and is usually eaten with fruits.

SCARMORZE.

This is a small, rennet cheese made in southern Italy from the milk of buffaloes

SCHAMSER.

This cheese, which is also known as Rheinwald, is a rennet cheese made from cows' milk, skimmed, in the Canton Graubünden, Switzerland. The cheeses weigh from 40 to 45 pounds each and are 18 inches in diameter and 5 inches thick.

SCHLOSS.

Schlosskäse, or Castle cheese, is a Limburg cheese made in the northern part of Austria. It is a soft-cured, rennet cheese 4 by 2 by 2 inches in size. When ready for market it is wrapped in tin foil.

SCHOTTENGSIED.

This is a whey cheese made for home use by the peasants of the Alps.

SCHWARZENBERG.

This cheese is made in southern Bohemia and western Hungary. It is a rennet cheese made from partly skimmed milk of cows. One part of skimmed milk is added to two parts of fresh milk. In about one hour after the addition of rennet the curd is broken up and thoroughly stirred. It is then dipped into wooden forms and light pressure applied for half a day. For four or five days following, the cheese is rubbed with salt and is then taken to the cellar, where it is washed daily with salt water until ripe, which requires two or three months.

SÉNECTERRE.

This is a soft, rennet cheese originating at Saint Nectaire, in the Department of Puy-de-Dôme, France. It is made of whole milk, is cylindrical in shape, and weighs about 1½ pounds.

SEPTMONCEL.

This is a hard, rennet cheese made from cows' milk, to which a small proportion of goats' milk is sometimes added. It resembles the Gex and Sassenage varieties very closely, and its process of manufacture is almost identical with that of Roquefort. It is also known as Jura blue cheese. It derives its name from the village of Septmoncel, near Saint Claude, in the Department of Jura,

where for the most part the cheese is made. It is made almost exclusively on isolated farms rather than in cooperative dairies, and the methods used are somewhat rudimentary.

The milk, which is usually partly skimmed, is set with rennet at a temperature of about 85° F. The curd is cut and stirred after about one and a half hours. After it has settled the whey is poured off. The stirring and draining are repeated several times until the curd is sufficiently firm to put into hoops. Moderate pressure is applied for a few hours. The cheese is salted at the end of 24 hours, and thereafter daily for several days. It is then transferred to the first curing room, which is kept cool and moist. After three or four weeks it has become covered with blue mold, when it is transferred to cellars or natural caves, where the ripening is completed in from three to four weeks longer.

SERRA DA ESTRELLA.

This is the most highly prized of the several kinds of cheeses made in Portugal. The name refers to the mountainous region in which the cheese is produced. For the most part it is made from the milk of sheep, but goats' milk is often added, or even used alone, and occasionally cows' milk is used.

The method of making this cheese is comparatively simple. The milk is warmed in a kettle with little regard to the temperature obtained, and in most cases is coagulated by means of an extract of the flowers of a kind of thistle. The time required for curdling varies from two to six hours, depending upon the quantity of the extract used. The curd is broken up with a ladle or by hand, squeezed to remove most of the whey, and put into circular forms. After draining until sufficiently firm, the cheeses are removed from the hoops and allowed to ripen for several weeks, during which time they are frequently washed with whey and salted on the surface. The cheeses vary much in size, the larger measuring about 10 inches in diameter and 2 inches thick, and weighing about 5 pounds. The cheese is rather soft and has a pleasant, acid taste.

A similar cheese, made in another part of Portugal, is known as Castello Branco.

SERVIAN.

In making Servian cheese the milk is warmed in a kettle over a fire or in a tub by immersing heated stones. After the rennet is added the milk is allowed to stand one hour, when the curd is lifted in a cloth and the whey allowed to drain. It is then placed in a wooden vessel, salted, and covered successively with whey for about eight days and fresh milk for about six days.

SILESIAN.

A cheese known locally as Schlesischer Weichquarg is made from cows' milk, skimmed, the process of manufacture resembling that of Hand cheese. The milk is allowed to coagulate from souring, and the curd is broken up and cooked at 100° F. for a short period. The curd is then put into a cloth sack and light pressure applied for 24 hours, after which it is kneaded by hand, and salt and milk or cream are added. Flavoring substances, such as onions or caraway seed, are also sometimes added. The cheese is eaten fresh.

Another cheese, known as Schlesischer Sauermilchkäse, is also made in much the same way as Hand cheese. The cheeses are kept on shelves covered with straw and are dried by the stove in winter and in a latticework house in summer. Drying is continued until the cheese becomes very hard. It is ripened in a cellar, the process requiring from three to eight weeks, during which time it is washed with warm water every few days.

SIRAZ.

This is a Servian cheese made as a rule from whole milk. The milk is set at 104° F., and the curd is lifted from the whey with a cloth and pressed into cakes from 4 to 6 inches in diameter and 1 inch thick. The cakes are placed in the sun to dry until the fat commences to run, when they are rubbed several times with salt until a good crust is formed, after which they are packed in a wooden vessel and allowed to ripen. The cut surface shows a smooth appearance without holes. It is between a hard and a soft cheese.

SIR IZ MJESINE.

This cheese is made in the Province of Dalmatia, Austria, from sheep's milk, skimmed. The milk is warmed in a bottle over the fire, and sufficient rennet, made from the dried stomachs of calves or swine, is used to coagulate it very quickly. The curd is broken up with a wooden spoon, is placed over the fire and stirred by hand. When sufficiently "firmed," it is placed in forms 8 inches square and pressed into cakes 2 inches thick. It is dried for a day and cut into cubes, salted, and packed in green hides, either goat or sheep. This cheese is sometimes left in the larger cakes and eaten when fresh.

SIR MASTNY.

This is a rennet cheese and is made in Montenegro from sheep's milk, freshly drawn. The curd is cut coarse and then heated to from 95° to 130° F.

SIR POSNY.

This cheese is sometimes called Tord, sometimes Mrsav. It is made in Montenegro from the skimmed milk of sheep. It is set with rennet, cut coarse, and heated to 99° F. It is a white, hard cheese and has many small holes.

SLIPCOTE.

This cheese is made in Rutlandshire, England. It is a soft, unripened rennet cheese, made from cows' milk. The curd is dipped into small forms, and no pressure is applied. After the cheese is removed from the form the surface dries and cracks and is easily slipped off; hence the name. It is an old variety, having been well known in the middle of the eighteenth century

SPALEN.

This is a type of Emmental cheese and is sometimes known as Stringer. Its origin is unknown. It is made largely in the Canton of Unterwalden, Switzerland, from cows' milk, sweet or partly skimmed. The name is derived from the vessel in which the cheeses are transported and in which five or six of them are packed. This is a small cheese for an Emmental type, each cheese weighing from 35 to 40 pounds.

No thermometer is used in the manufacture, the temperature being judged by the feeling, and a very uneven product is the result. The process of making seems to vary much, the press consisting of a board with stones for weights, and the temperature of the cellar being poorly regulated.

SPITZ.

This is a small, rennet cheese made from cows' milk. The cheese is cylindrical in shape, being 4 inches high and 1½ inches in diameter.

STEPPES.

This name is applied to a Russian cheese made from whole milk. The milk after the addition of coloring matter is heated to about 90° F. and treated with sufficient rennet to coagulate it in 40 or 45 minutes. The curd is cut into large cubes, the whey removed slowly, and the curd still further broken up until the particles are uniformly about the size of peas. The curd is then heated gradually to 100° or 104° F., the mass meanwhile being gently agitated. After heating ceases, the stirring is kept up until the curd becomes dry, when it is placed in molds 10 by 5½ by 7 inches. After the cheeses are removed from the molds they are turned frequently and five hours later are salted and transferred to the curing cellar, where a temperature of about 55° F. is maintained. During the process of ripening the cheeses are worked occasionally with salt water and frequently turned.

STILTON.

This is a hard, rennet cheese, the best of which is made from cows' milk to which a portion of cream has been added. It was first made near the village of Stilton, Huntingdonshire, England, about the middle of the eighteenth century. It is now made principally in Leicestershire and western Rutlandshire, though its manufacture has extended to other parts of England. Its manufacture has been tried, though without success, in the United States. The cheese is about 7 inches in diameter and 9 inches high and weighs 12 or 15 pounds. It has a very characteristic wrinkled or ridged skin or rind, which is probably caused by the drying of molds and bacteria on the surface. When cut it shows blue or green portions of mold which give its characteristic piquant flavor. The cheese belongs to the same group as the Roquefort of France and the Gorgonzola of Italy.

The morning's milk is put into a thin vat, the cream from the night's milk is added, and the whole is brought to a temperature of 80° F., when the rennet is added. It is claimed by some cheesemakers that the curd should be softer when broken up or cut than the curd for Cheddar cheese, while by others it is believed that it should become very firm before it is disturbed, allowing one or two hours for setting. When sufficiently firm, the curd is dipped into cloths which are placed in tin strainers. After draining for one hour, the cloths containing the curd are packed closely together in a large tub and allowed to remain for 12 hours, when they are again tightened and packed for 18 hours. The curd is ground up coarse, and salt is added, 1 pound to 60 pounds of curd. It is then put into tin hoops 8 inches in diameter and 10 inches deep. The cheeses remain in the hoops for six days, when they are bandaged for 12 days, or until they become firm, and are then placed in the curing room at 65° F. Ripened Stilton cheese of late is often ground up and put into jars holding from 1 to 2½ pounds.

STRACCHINO.

This name is applied to several forms of soft cheeses made in Italy, the best known of which is Stracchino di Gorgonzola, described under the name of Gorgonzola. A square form 6 or 8 inches on a side and 1½ inches thick is known as Stracchino di Milano, Fresco, Quadro, or Quartirola. This cheese is prepared similarly to Gorgonzola but is allowed to ripen for only about two months. Very little is exported. Stracchino Crescenza is a very soft and highly colored cheese, usually eaten fresh. The form is similar to that of the Quartirola. It is usually marketed in about eight days and can not be kept long.

STYRIA.

This is a cylindrical-shaped cheese made from cows' milk, unskimmed, in Styria, Austria.

SWEET CURD.

This is a name applied in the United States to a hard, rennet cheese made from cows' milk. The name is used to distinguish it from the ordinary Cheddar or granular process, as in making Sweet-Curd cheese the milk is set sweet, and the cutting and cooking are done rapidly without regard to the development of acid. In making this cheese the curd is cooked very firm and is salted and put to press immediately. In all other respects the process is the same as for Cheddar, and the cheese when ripened resembles that cheese very closely.

SWISS.

Swiss or Schweitzer cheese belongs to the Emmental group of cheeses and is made usually from cows' milk, half skimmed. Its manufacture is very old. It is supposed to have originated in the Alps, but is now made in most of the surrounding countries. It is made mostly in the winter season, when the price of butter is high, and only for local consumption. Its manufacture differs from real Emmental in that it is made from half-skimmed milk. The morning's milk is first heated, and the skimmed milk of the previous evening is added. The curd is cut coarser and is not cooked so firm as Emmental, which gives a softer and more quickly ripened cheese.

The cheese made in the United States which goes by the name of Swiss or Domestic Swiss is in reality an imitation of the Emmental cheese, as it is made from whole milk.

TAFI.

This cheese is manufactured in the Province of Tucuman, in the Argentine Republic.

TAMIÉ.

This cheese is made by the Trappists in Savoy, France. The whole milk is heated to about 80° F. and coagulated with rennet in about 30 minutes. The curd is cut fine, cooked to about 100° F., stirred, and put into molds 7 inches in diameter and 4 inches in height. The cheese is pressed for from six to eight hours, the cloths being changed frequently. After being salted the cheese is ripened for five or six weeks. The method of manufacture is, to a large extent, a trade secret. The Tome de Beaumont is a more or less successful imitation.

TELEME.

This cheese, sometimes known as Branza de Braila, is made in Roumania from sheep's milk. The milk is set at 86° F., and after the curd is broken up the mass is put into a linen sack and cut into forms 2 inches by 2 inches by 1 inch, and the form, with the cheese, is placed in brine. This cheese is marketed when 10 days old.

TEXEL.

This is a sheep's-milk cheese made in Holland and was known in the seventeenth century. A cheese weighs 3 or 4 pounds and is colored green.

THENAY.

This is a soft, rennet cheese resembling Camembert and Vendôme and is made in the region of Thenay, in the Department of Loir-et-Cher, France. It is of

comparatively recent origin, and its consumption is limited practically to the region in which it is produced.

The evening's milk without being skimmed is mixed with the fresh milk of the next morning. The milk is set with rennet at a temperature of about 85° F. and allowed to stand for four or five hours. The curd is then broken up and put into hoops about 5 inches in diameter and 4 inches in height. After draining for about a day it is turned and salted. The cheese is then kept for about 20 days in a well-ventilated room, during which time it becomes covered with molds. It is then stored in the curing cellar for about 15 days.

TIBET.

The so-called Tibet cheese is a sheep's-milk cheese made in Tibet. The small cheeses, in cubes of about 2 inches, are strung on strings, 50 to 100 on each. This cheese is hard and is used for grating.

TIGNARD.

This is a hard, rennet cheese, resembling Gex and Sassenage, made from sheep's or goats' milk in the valley of the Tigne, in Savoy, France.

TILSIT.

This is a hard, rennet cheese made mainly in East Prussia from cows' milk, unskimmed. It is sometimes called Ragnit. The milk is set at 92° F., with sufficient rennet to coagulate in from 15 to 40 minutes. The curd is rather coarsely cut or broken and is cooked at a temperature of from 104° to 110° F., being stirred meanwhile with a harp. The curd is cooked about 40 minutes, or until it is quite firm and can not be squeezed through the fingers. It is then dipped into cylindrical forms, where it remains 24 hours. The cheese is then covered thickly with salt for from one to two days, when it is put into a salt bath from three to five days and then transferred to the cellar, where it is rubbed and washed frequently with salt water, and allowed to ripen for from four to six months. The cheese is from 6 to 12 inches in diameter, 3 to 4½ inches in height, and weighs from 6 to 28 pounds. It resembles in general characteristics the Brick cheese of the United States.

TOPPEN.

This is a sour-milk cheese made in Germany from skim milk and eaten while fresh. It is put up in small packages weighing about 1 ounce.

TOUAREG.

This is a rennet cheese made from skimmed milk by the Berber tribes, from the Barbary States to Lake Tchad, in Africa.

The coagulated milk or soft curd is dipped, in very thin layers, on to mats, where it stays until it will retain its shape. It is then placed in the sun for ten days or before a fire for six days, being turned a number of times. It is very hard and dry and is not salted. To curdle the milk some of the natives ues the leaves of a tree called Korourou.

TRAPPIST.

This cheese originated with the Trappists in 1885 in the monastery of Mariastern, near Banjaluka, in Bosnia. The fresh milk is heated to about 85° F., and rennet is added. After from one to two and one-half hours the curd, without

being cut or stirred, is put into hoops and pressed, after which it is salted and ripened. The growth of mold is entirely prevented by frequent washing, and thus the cheese ripens uniformly throughout. The ripening period of the smaller cheeses is from five to six weeks in summer, but the cheese is usually shipped at the end of four or five weeks. It is pale yellow in color and has a remarkably mild taste. Although it is to be classed among the soft varieties, the water content is often below 45 per cent. The ripening is also more characteristic of the hard cheeses. The smallest size of the cheese made in the monastery referred to has a diameter of 6 inches, a height of 2 inches, and weighs 2 or 3 pounds. A larger size measures 9 inches in diameter, 2½ inches in height, and weighs about 10 pounds. There is also a still larger size. The cheese is exported to a large extent to Austria and Hungary, the most important centers of the trade in these regions being Gratz and Budapest. It is, however, found in all the large cities of Austria, and the demand appears to be constantly increasing. This cheese is very probably the same as Port du Salut.

A cheese which is probably identical with the Trappist, or Port du Salut, is made in the Trappist monastery at Oka, Canada, and goes by the name of Oka cheese.

TRAVNIK.

This is a soft, rennet cheese made usually from sheep's milk, whole, to which a small quantity of goats' milk is added. Skimmed milk, however, is sometimes used. It is also known as Arnauten and Vlasic. This cheese originated in Albania, in the northwestern part of Turkey, in Europe, and has been made for at least a century. In the country of origin it was known at first by the name Arnautski Sir or Arnauten cheese. At the present time it is made in Bosnia and Herzegovina, but principally in the Vlasic Plain. The center of trade in this cheese in Travnik in Bosnia.

The fresh, warm milk is treated with sufficient rennet to coagulate it in one and one-fourth to two hours and is then allowed to stand for a short time until the coagulum contracts and the whey appears on the surface. The curd is then put into woolen sacks and drained for seven or eight hours, when it is pressed into flattened balls by hand. These balls are dried for a short time in the open air and are then packed into wooden receptacles varying in diameter from 14 to 28 inches, having a height of about 24 inches, and holding from 50 to 130 pounds of cheese. Each layer of cheese is salted and pressed, so that no air spaces are left. When the receptacle is filled the whey usually shows at the surface, any excess being removed. Moderate pressure is applied to the cover placed upon the cheese. When fresh, the cheese made from sheep's milk, whole, has a soft consistency, a nearly white color, and a pleasant, mild taste. The cheese, however, is usually allowed to ripen from two weeks to several months. No holes should develop in it.

TROUVILLE.

This is a soft, rennet cheese made in the same locality as Pont l'Évêque and is of the same nature though superior in quality. Only fresh, whole milk is used. The temperature of setting with rennet is from 85° to 95° F. The growth of molds during the process of ripening is prevented by frequent washing with salt water.

TROYES.

Two kinds of cheese are referred to by this name—one a washed cheese with a yellow rind, known as Ervy, and the other a cheese very closely resembling Camembert and known as Barberey. The industry is rather restricted.

TSCHIL.

This cheese is also known as Leaf, Telpanir, and Zwirn. It is made in Armenia from either cows' or sheep's milk, skimmed. The milk, evidently soured, is hung over a fire and heated to 122° F. With the hand the curd is kneaded in the bottom of a kettle until it becomes tough and is then pressed into cakes. These cakes are salted in a wooden trough and ripened for from five to eight days. When a sufficient number is on hand the cakes are broken up and packed in skins.

TUNA.

Tuna cheese is a Mexican product which has been of local importance from an early date. It is really a confection rather than a cheese, being made from the fruit of the *Tuna cardona*, or sometimes the *Tuna pachona*. The product is made by boiling and straining the Tuna pulp until a cheeselike consistency is reached, sometimes with the addition of nuts or flavors. It is of a chocolate color, pleasant to the taste, and wholesome. It is said to keep in good condition for a very long time.

TWDR SIR.

This cheese, a Serbian product, is made from sheep's milk, skimmed, and set with rennet at about 104° F. The curd is cut and is lifted from the whey with a cloth, salted lightly, and pressed in forms 10 or 12 inches in diameter and 2 inches high. This cheese has small holes, a sharp taste, and probably is similar to Brick or Limburger.

TWOROG.

This is a sour-milk cheese made in Russia. The soured milk is kept in a warm place for 24 hours, when the whey is removed and the curd put into wooden forms and subjected to pressure. This cheese is made on a large scale by farmers and is often used in making a bread called "Notruschki."

URI.

This is a hard, rennet, cows'-milk cheese made in the Canton of Uri, Switzerland. It has a diameter of from 8 to 12 inches, is 8 inches high, and weighs from 20 to 40 pounds.

VACHERIN.

This name applies to two quite different kinds of cheese. The form designated Vacherin à la Main is made in Switzerland and in Savoy, France. Cows' milk, whole, is set with rennet at a temperature of about 85° F., and the curd is cut very fine and put into hoops 12 inches in diameter and 5 or 6 inches high. It is salted and ripened. The rind is firm and hard, but the interior is almost liquid in consistency. The cheese is either spread on bread or eaten with a spoon, and weighs from 5 to 10 pounds. A cheese of this kind made in the same region is known locally as Tome de Montagne.

The form designated Vacherin Fondu is made in much the same manner as Emmental cheese. The ripened cheese is then melted, and spices are added.

VENDÔME.

This is a soft, rennet cheese resembling Camembert and Thenay, and is made in the region of Vendôme in the Department of Loir-et-Cher, France.

The warm, morning's milk is usually mixed with that of the previous evening, which produces ordinarily a setting temperature of 75° or 85° F. The period

of setting is four or five hours in summer and five or six hours in winter. The curd is then broken up and put into hoops about 5 inches in diameter and 4 inches in height. After draining for 24 hours, the cheese is turned and salted, which process is twice repeated every 12 hours. When sufficiently dried, it is placed in the curing cellar, where it is sometimes buried in ashes. This cheese is placed by some on a par with Camembert. The principal market is Paris.

VILLIERS.

This is a square, soft, rennet cheese weighing about 1 pound, made in the Department of Haute-Marne, France.

VOID.

This is a soft, rennet cheese resembling Pont l'Évêque and Limburg. It is made in the Department of Meuse, France. The milk is set with rennet at a high temperature, the whey is removed as rapidly as possible, and the cheeses during ripening are washed frequently with salt water.

VORARLBERG SOUR-MILK.

This, as the name indicates, is made from sour milk of cows. It is semicircular in shape and varies in size. It is essentially a hard cheese.

The sweet milk is put into a kettle and raised to 77° F., sour-thickened milk is added, and the mixture is stirred and heated to 95° F., at which temperature it coagulates. While this is being stirred with a curd scoop the temperature is raised to 105° F. The curd is then dipped into forms, where it is turned a few times during 24 hours. Salt is rubbed on the surface, and the cheese is placed in a room having a temperature of 67° F. The cheese is then placed in a cask and held for three days, and salt is sprinkled over the surface daily. The ripening is completed in a cellar. When ripe the cheese is greasy and has a very strong odor and flavor.

WEISSLAK.

This is a soft-cured, rennet cheese made from cows' milk in the Bavarian Algau, Germany. The cheese weighs about 2½ pounds and is rectangular in shape, 4½ by 4 by 3½ inches.

WENSLEYDALE.

This is a rennet cheese made from whole milk of cows and derives its name from the valley in Yorkshire, England, in which it originated. It is cylindrical in shape and weighs from 5 to 15 pounds.

In the old method of manufacture the evening's milk is heated to 100° F., and the fresh, morning's milk is added. It is set with sufficient rennet to coagulate it in 35 minutes. The breaking or cutting process requires 35 minutes, after which the curd is allowed to stand for 45 minutes at 90° F. The whey is then removed, and the curd is put into vats lined with cloth, and light pressure is applied for 30 minutes. The curd is broken up and allowed to drain for one hour. It is then milled and is pressed for 24 hours, when it is wrapped in cloth and finally put into brine for three days.

In the new method of manufacture the evening's milk is mixed with the morning's milk in a copper kettle, heated to 95° F., and rennet enough is added to coagulate it in 45 minutes. The curd is then broken up by hand or with a breaker. The whey is removed and the curd dipped into tin hoops, where it

drains for three hours. It is then turned and drained for another three hours. After pressing for 24 hours, the cheese is salted by immersion in brine for three days.

WEST FRIESIAN.

This is a rennet cheese made from cows' milk, skimmed. The milk is set in a copper kettle, one hour being allowed for coagulation. The curd is broken up and placed in a wooden tub, where it is kneaded. The curd is allowed to stand for several hours and then salted. It is pressed for three hours, washed in hot water, wrapped in a fine cloth, and again pressed for 12 hours. The cheese is eaten when one week old.

WESTPHALIA SOUR-MILK.

This is a hand cheese made in Westphalia. Sour milk is stirred and heated to 100° F., placed in a sack, and the whey pressed out. The curd is then kneaded by hand and salted, butter and caraway seed or pepper being added. It is then molded by hand, dried for a few hours, and ripened in a cellar.

WHITE.

Fromage Blanc, or White cheese, is a skim-milk cheese made in France during the summer months. The milk is set with rennet at about 75° F. The curd is usually molded into cylindrical forms. The cheese is consumed while fresh and may or may not be salted.

WITHANIA.

This is so called because made with rennet manufactured from withania berries. Cheese made with the rennet of these berries is said to have an agreeable flavor if ripened to the right degree, but with age it develops an acrid flavor. The texture is not so good as with animal rennet. This form of rennet is recommended for use in India, where the religion and prejudice of the people make the use of animal rennet impracticable.

YOGURT.

This name has been applied to cheese made in limited quantities in the United States where cultures of the *Bacillus bulgaricus* have been used for developing the acidity of the milk. A similar cheese made in England is called Saint Wel.

ZIEGEL.

This is a cheese made in Austria either from cows' milk, whole, or from whole milk to which 15 per cent of cream has been added. The cheese measures 3 by 2 by 2½ inches, and weighs about one-half pound.

In making the whole-milk cheese the milk is warmed to 95° F. and sufficient rennet is added to coagulate it in 30 minutes. The curd is broken up with a harp and cut loose from the bottom of the vessel, after which it is allowed to remain undisturbed for 30 minutes. At the end of this time the curd, which is again matted together, is cut into pieces and stirred gently for a considerable time, after which it is allowed to stand again for 15 minutes. The collected whey is then dipped off, and the curd is dipped into forms which are 24 inches long, 5 inches high, and hold the curd of 7½ or 8 gallons of milk. Before the form is filled, a cheesecloth is placed in it, which helps in turning the curd. The curd remains in the form 24 hours to drain, and is then cut into measured sizes and placed in another form, where it is allowed to remain for eight days, the curd being turned and the board on which the form rests being changed

daily. Salt is then sprinkled on the cheese, and for one month it is washed in salt water and rubbed with the hands every day. It is ready for market in eight weeks from the time of making.

ZIGER.

This is a cheese made from the whey obtained in the manufacture of other cheese. It consists principally of albumin, but if no effort is made to separate the fat from the whey the product may contain a relatively high proportion of fat. It is a cheap food product made in all the countries of central Europe. Among the many names applied to it are Albumin cheese, Recuit, Ricotta, Broccio, Brocotte, Sérac, and Ceracee.

In the manufacture of this product an effort is sometimes made to remove the fat remaining in the whey, but in most cases it is allowed to remain. Where it is desired to skim the whey, a small portion of very sour whey, previously prepared, is added to the sweet whey, and the whole is heated to 160° or 175° F. for a few minutes, when the fat collects on the surface and can be skimmed off. Following this, a greater portion of sour whey is added and the whey is then heated nearly to the boiling point, when the albumin is precipitated in a flocculent condition and rises to the surface. When the whey is not in normal condition the albumin may be precipitated in a powdery mass. This is often prevented by adding 3 to 5 per cent of buttermilk to the whey before the last heating. The casein of the buttermilk is precipitated, the albumin being carried with it. It is considered that this addition of casein injures the product. The albumin when skimmed from the whey is salted and packed in a vessel and may be covered with whey.

A cheese called formed Ziger is made by molding the half-dried albumin into squares, which may be still further dried. Some of these have local names, such as the Hudelziger, made in the Canton of Glarus, Switzerland.

In Vorarlberg the albumin is skimmed from the whey, allowed to cool, placed in cheesecloth, and subjected to increasing pressure in an Emmental cheese press. After 24 hours the cheese is put into a salt bath, to which sweet cider or vinegar is sometimes added.

A mixture of Ziger and cream prepared in the Savoy is known as Gruau de Montague. An albumin cheese made from the whey of goats'-milk cheese in the Canton of Graubünden, Switzerland, is known as Mascarpone.

In New York there are factories that make this cheese, label it "Ricotta," and sell it to Italians.

ANALYSES OF CHEESE.[1]

Variety.	Authority.[2]	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Alemtejo	Hoffman	1	30.22	38.25	20.87	3.06	7.60	2.90
	Pereira	4 Average	41.11	27.49	21.45	4.06	6.07	2.05
		4 Maximum	48.39	31.59	24.33	5.24	6.40	3.20
		4 Minimum	32.97	25.27	17.77	3.82	5.87	1.18
Backstein	Fleischmann	2	73.12	2.76	19.84	2.17	2.11	.....
		2	61.04	6.80	23.85	3.48	4.83	.....
	Lindt	2	45.24	28.16	23.14	.....	3.46	.....
		2	35.80	37.40	24.44	.....	2.36	.....
Battelmat	Eugling	7 Average	47.71	24.08	22.99	2.35	2.87	.....
		7 Maximum	50.53	29.42	24.48	3.35	3.14	.....
		7 Minimum	44.24	20.52	21.22	2.25	2.71	.....

[1] These analyses are copied principally from literature and are not vouched for by authors.
[2] See Sources of analytical data for details.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Bellelay	Benecke	1	39.62	30.10	25.70	.....	4.72	3.35
	Lindt	1	37.59	30.05	28.88	.....	3.48	.....
Bondon	Chattaway	1	39.50	24.40	9.40	.....	.70	.....
	Lindet	1	54.30	23.00	16.10	.....	5.00	4.30
Brick	Weems	1	38.69	28.86	23.80	.....	4.20	.....
	Bureau of Chemistry.	Average	42.47	30.66	21.05	.....	2.98	.....
		4 Maximum	45.26	33.77	23.29	.....	4.20	.....
		Minimum	39.61	28.34	20.03	.....	1.68	.....
Brie—Imported	Balland	2	48.80	22.45	19.94	4.85	3.96	.....
			43.90	28.93	19.04	6.63	1.50	.....
	Blyth	1	51.90	24.80	18.10	.....	5.00	.....
	Duclaux	Average	50.04	27.50	18.34	.....	4.12	3.22
		5 Maximum	53.84	29.50	19.94	.....	4.37	3.70
		Minimum	46.06	24.60	17.16	.....	3.57	2.67
	Von Klenze	1	55.69	21.42	17.29	.....	5.60	.....
	Lindet	1	53.50	22.50	18.00	.....	4.00	3.20
	Payen	2	53.99	24.83	14.94	.....	5.63	.....
			45.25	25.73	18.48	4.93	5.61	.....
	Bureau of Chemistry.	Average	52.53	22.44	20.94	.....	4.81	.....
		6 Maximum	58.93	25.64	24.05	.....	5.25	.....
		Minimum	48.16	19.71	17.03	.....	4.39	.....
Brie—American	Arnold	1	41.50	36.15	17.63	.....	4.70	.....
	Johnson	1	60.20	20.96	15.94	1.37	1.53	.40
	Bureau of Chemistry.	Average	52.10	24.72	19.60	.....	4.06	.....
		12 Maximum	59.20	30.71	23.35	.....	1.13	.....
		Minimum	42.93	15.53	14.80	.....	.....	.....
Brinsen	Maior	2	49.20	22.30	23.10	1.00	4.40	.....
			37.70	32.60	25.20	2.70	5.80	.....
	Melikoff	3	43.10	27.70	19.90	1.20	7.30	.....
			49.70	27.00	14.30	1.80	6.80	.....
			52.20	26.20	14.40	1.30	6.00	.....
Burgundy	Balland	1	29.50	38.55	28.84	1.65	1.46	.....
Caciocavallo	Sartori	2	19.76	36.71	37.83	.....	5.60	3.26
			22.09	35.90	36.06	.....	5.80	3.16
	Spica	Average	23.68	25.49	29.25	.....	7.63	3.39
		9 Maximum	33.24	30.09	35.09	.....	10.50	6.23
		Minimum	15.34	19.00	22.16	.....	5.79	2.10
	Bureau of Chemistry.	Average	34.95	21.98	34.33	.....	6.96	.....
		4 Maximum	39.75	27.08	42.55	.....	7.77	.....
		Minimum	32.20	12.88	30.88	.....	5.08	.....
Caerphilly	Chattaway	1	24.80	30.40	37.20	.....	3.40	.....
Cambridge	Chattaway	1	32.10	47.10	24.60	.....	4.40	.....
Camembert—Imported.	Arnold	1	50.41	20.55	25.49	.....	3.52	.....
	Balland	1	49.00	21.65	18.72	5.95	4.68	.....
	Chattaway	2	47.90	21.90	21.80	.....	4.70	.....
			43.40	22.60	24.40	.....	3.80	.....
	Duclaux	1	45.24	30.31	19.75	.....	4.70	3.69
	Krüger	1	59.42	17.24	17.13	4.70	1.56	.....
	Lindet	1	53.80	22.00	17.10	.....	4.40	3.20
	Macoir	1	49.87	25.54	18.76	.....	5.83	4.01
	Muter	1	48.78	21.35	21.07	.....	3.46	.....
	Payen	1	51.94	21.05	18.90	4.40	4.71	.....
	Rollet	1	52.98	23.71	19.12	.....	4.19	3.21
	Stutzer	1	50.90	27.30	18.66	.....	3.14	2.21
	Bureau of Chemistry.	Average	47.88	26.32	22.21	.....	4.11	.....
		49 Maximum	61.14	39.76	30.43	.....	5.55	.....
		Minimum	24.74	13.94	14.86	.....	2.66	.....
American	do	6 Average	47.37	26.58	23.18	.....	3.98	.....
		1 Maximum	57.87	40.08	32.16	.....	6.86	.....
		Minimum	29.20	10.44	16.84	.....	2.51	.....
	Dox and Edmond	12 Average	47.91	27.33	19.66	.....	.....	.....
Cantal	Balland	3	28.50	34.10	28.38	4.46	4.56	.....
			35.10	28.30	24.98	7.22	4.40	.....
			39.00	26.90	24.22	5.93	3.95	.....
	Duclaux	Average	43.48	25.70	22.55	6.47	.....	2.05
		4 Maximum	44.80	31.10	24.10	7.50	.....	3.10
		Minimum	40.70	22.50	21.50	4.30	.....	.80
	Lindet	1	40.90	29.30	20.50	.....	4.80	2.60
	Patrick (2)	1	39.92	28.14	28.84	.....	4.50	.....
Cheddar—American	Caldwell	Average	34.04	35.56	26.87	.....	3.40	.....
		8 Maximum	38.50	41.03	28.15	.....	4.05	.....
		Minimum	28.11	31.19	25.57	.....	2.71	.....
		Average	24.93	32.62	38.01	.....	4.42	.....
	Cooke	3	35.38	32.50	23.91	.....	3.73	.....
			37.56	27.70	25.58	.....	3.96	.....
			34.62	37.52	20.19	.....	3.71	.....
	Drew	201 Average	31.05	35.54	33.41	.....	.....	.....

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
Cheddar—Continued.			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
American	Goessmann	6 Average	40.32	26.05	29.89	.....	3.74	.....
		6 Maximum	45.41	37.32	34.94	.....	5.14	.....
		6 Minimum	35.83	15.77	22.13	.....	2.35	.....
	Patrick (1)	151 Average	33.09	38.78	21.93	1.99	4.09	.....
		151 Maximum	38.36	49.56	31.76	2.34	4.73	.....
		151 Minimum	26.48	24.77	15.38	1.65	2.43	.....
	Snyder	5 Average	32.71	35.25	26.81	.....	.....	.....
	Van Slyke	50[2] Average	37.14	34.65	23.64	.....	[3]4.57	.....
		156[4] Average	36.84	33.83	23.72	.....	[3]5.61	.....
		156[4] Maximum	43.89	36.79	26.11	.....	7.02	.....
		156[4] Minimum	32.69	30.00	20.80	.....	3.12	.....
		9[5] Average	36.06	34.43	24.45	.61	3.61	.....
		9[5] Maximum	41.15	45.36	28.72	.76	5.29	.....
		9[5] Minimum	32.23	23.27	18.45	.51	1.81	.....
		6[6] Average	34.01	36.81	25.69	.....	[3]3.50	.....
		6[6] Maximum	38.10	44.33	30.09	.....	4.59	.....
		6[6] Minimum	29.85	27.22	21.53	.....	2.72	.....
	Voelcker	4 Average	32.39	31.44	26.57	5.02	4.57	1.49
	Wallace	15[7] Average	36.42	36.95	21.15	1.36	3.81	.....
		15[7] Maximum	41.65	46.80	32.09	2.68	4.61	.....
		15[7] Minimum	30.25	21.77	14.11	.41	2.55	.....
	Wilson	3	30.53	41.58	23.38	2.45	2.06	.....
			31.70	36.18	27.19	1.95	2.98	.....
			43.82	5.98	45.04	3.12	2.06	.....
Skimmed—								
	Bureau of Chemistry.	121 Average	57.04	4.88	32.09	.....	3.76	.....
		121 Maximum	67.25	6.08	36.81	.....	4.71	.....
		121 Minimum	50.39	2.67	22.65	.....	2.03	.....
Partly skimmed—								
	Bureau of Chemistry.	27 Average	38.91	18.16	35.38	.....	3.74	.....
		27 Maximum	55.93	26.04	36.37	.....	4.31	.....
		27 Minimum	33.67	7.73	22.14	.....	2.88	.....
Cheddar—								
Canadian	Chattaway	1	33.30	30.60	27.60	.....	3.60	.....
	Clark	11 Average	34.07	22.54	40.02	.....	3.45	.....
		11 Maximum	36.58	25.67	43.52	.....	3.93	.....
		11 Minimum	32.28	20.13	33.82	.....	3.14	.....
	Shuttelworth	5[7] Average	34.60	35.51	23.18	.....	[3]6.70	.....
		6[8] Average	32.53	36.06	23.94	.....	[3]7.48	.....
		135[9] Average	36.54	33.81	23.96	.....	[3]5.60	.....
		135[9] Average'	33.51	32.97	24.94	.....	[3]8.58	.....
Cheddar—								
English	Blyth	2 Average	28.10	22.50	45.60	.....	4.10	.....
	Chattaway	4 Average	35.00	29.02	27.72	.....	3.12	.....
		4 Maximum	37.70	30.50	29.00	.....	4.30	.....
		4 Minimum	33.00	25.00	26.70	.....	3.00	.....
	Griffiths	1	36.34	34.36	22.98	2.10	4.22	.....
	Hassall	1	30.10	36.54	30.15	.....	3.21	.....
	Jones	1	36.04	30.40	28.98	.....	4.58	.....
	Lloyd	31 Average	35.52	30.33	30.04	.....	4.05	.....
		31 Maximum	37.73	34.65	35.10	.....	4.60	.....
		31 Minimum	32.85	24.00	22.77	.....	3.40	.....
	Voelcker	13 Average	35.16	30.45	27.80	3.16	3.42	.70
		13 Maximum	39.43	41.58	32.37	6.80	4.31	1.55
		13 Minimum	30.32	23.21	23.28	.22	2.06	.09
	Von Klenze	1	35.22	27.91	33.47	.....	3.40	.....
Cheddar—								
Queensland	Brunnich	2	31.62	35.17	24.59	.....	4.09	1.44
			27.67	37.35	26.24	.....	4.04	.....
Cheshire	Arnold	1	24.69	37.08	33.36	.....	4.85	.....
	Balland	1	22.60	39.50	27.16	6.80	3.94	.....
	Blades	6 Average	44.59	21.55	29.25	.....	4.61	.....
		6 Maximum	52.60	30.67	32.95	.....	5.00	.....
		6 Minimum	36.10	9.85	24.44	.....	3.90	.....
	Chattaway	2	37.80	31.30	25.70	.....	4.20	.....
			31.60	35.30	26.50	.....	4.40	.....
	Griffiths	1	27.55	36.00	31.00	2.21	3.24	.....
	Lindet	1	31.10	32.30	30.90	.....	3.70	1.30

[1] The 15 analyses are each the average of 5 monthly analyses. The green cheese was analyzed by Wallace.
[2] Green cheese made at New York State Agricultural Experiment Station, 1892.
[3] Sugar, ash, etc.
[4] Green cheese made at numerous factories in New York, 1892 and 1893.
[5] Age of cheese, seven weeks.
[6] Age of cheese, five months.
[7] Green cheese.
[8] Age of cheese, 1 month.
[9] Cured cheese.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*
Cheshire—Continued.	Payen	2	30.39	25.48	34.75	.....	4.78	.....
			35.92	26.34	25.99	7.59	4.16	.....
	Voelcker	2	36.96	29.34	24.08	5.17	4.45	1.91
			32.59	32.51	26.06	4.53	4.31	1.59
Club	Bureau of Chemistry.	24 Average	31.74	35.78	26.62	.....	4.00	.....
		24 Maximum	34.55	40.88	28.33	.....	4.57	.....
		24 Minimum	25.37	32.23	24.17	.....	3.29	.....
Cotherstone	Griffiths	1	38.20	30.25	23.82	3.81	3.92	.....
	Voelcker	2	38.28	30.89	23.93	3.70	3.20	.79
			38.23	29.12	24.38	2.76	5.51	2.55
Cottage	Bureau of Chemistry.	5 Average	69.82	1.03	23.26	.....	1.91	.....
		5 Maximum	72.98	1.94	32.47	.....	2.49	.....
		5 Minimum	63.46	0.87	20.16	.....	1.56	.....
Coulommiers	Balland	1	50.40	20.45	17.41	4.80	6.94	.....
	Lindet	2	53.00	21.50	16.90	.....	5.70	4.80
			57.80	25.00	13.00	.....	4.10	3.60
Cream—								
English	Chattaway	2	57.60	39.30	19.00	.....	3.40	.....
			14.00	68.10	20.10	.....	1.20	.....
	Hassall	1	30.34	67.32	2.02	.....	.32	.....
	Payen	1	9.48	59.88	18.40	5.77	6.47	.....
	Vieth	8 Average	36.49	56.08	5.28	1.27	.82	.....
		8 Maximum	47.94	66.80	8.77	2.50	1.48	.....
		8 Minimum	27.69	43.76	2.00	.22	.44	.....
Cream—								
French Demi-sel.	Balland	1	52.10	25.20	13.49	8.28	.93	.....
	Lindet	1	49.60	34.00	11.80	.....	3.00	2.40
	Bureau of Chemistry.	23 Average	42.74	39.88	14.49	.....	1.88	.....
		23 Maximum	57.33	48.65	18.31	.....	4.75	.....
		23 Minimum	34.15	28.40	10.08	.....	.99	.....
	Currie	4 Average	36.91	44.19	14.60	.....	.....	.....
		4 Maximum	44.00	48.00	16.02	.....	.....	.....
		4 Minimum	30.00	38.60	12.73	.....	.....	.....
Crescenza	Duclaux	1	56.75	21.34	18.91	.....	2.90	1.34
Danish Export	Storch	9 Average	45.99	13.41	30.01	5.10	3.63	1.86
		9 Maximum	49.88	23.70	34.00	5.90	4.17	2.55
		9 Minimum	38.78	9.34	27.69	2.65	3.33	1.11
Derbyshire	Sheldon	1	31.60	35.20	24.50	4.38	4.24	.....
Dorset	Griffiths	1	41.44	27.56	22.25	4.24	4.51	.....
	Vieth	1	41.55	8.76	44.09	.....	5.60	2.93
Dunlop	Jones	1	38.46	31.86	25.87	.....	3.81	.....
Edam	Arnold	2	29.23	28.71	33.89	.....	8.14	.....
			29.56	27.43	32.31	.....	8.49	.....
	Balland	2	37.90	25.90	27.32	4.08	4.80	.....
			38.50	24.29	25.34	9.07	2.80	.....
	Cribb	4 Average	51.66	11.85	26.82	.....	6.04	.....
		4 Maximum	60.38	24.40	31.92	.....	7.33	.....
		4 Minimum	41.70	3.83	24.00	.....	5.54	.....
	Dahl	3	32.57	32.19	23.98	6.35	4.67	.....
			33.62	33.99	23.48	6.34	2.42	.....
			42.85	26.73	19.39	5.15	5.62	.....
	Hassall	1	30.10	27.57	32.81	.....	6.84	.....
	Von Klenze	1	41.88	24.05	29.47	.....	4.60	.....
	Lindet	1	42.60	20.00	23.90	.....	5.50	3.20
	Mayer	1	33.20	28.00	29.60	2.60	6.60	3.30
	Patrick (2)	1	32.80	29.58	28.41	.....	5.55	.....
	Payen	2	36.10	27.54	29.43	.....	6.93	.....
			41.41	25.06	25.63	.....	6.21	.....
Edam-American	Haecker	3[1]	48.69	23.21	21.49	3.83	3.02	.....
			44.44	25.37	22.69	3.79	2.59	.....
			46.80	23.30	24.24	2.92	3.68	.....
	Van Slyke	18[1] Average	47.55	24.42	22.18	.....	[2] 5.80	.....
		18[1] Maximum	55.34	31.75	24.70	.....	9.46	.....
		18[1] Minimum	41.25	19.73	18.95	.....	2.51	.....
	Bureau of Chemistry.	53 Average	38.07	22.65	30.89	.....	6.19	.....
		53 Maximum	47.27	31.85	40.64	.....	8.59	.....
		53 Minimum	28.87	7.67	24.75	.....	3.81	.....
Emmental	Benecke	7 Average	37.77	23.92	30.97	.....	6.85	3.80
		7 Maximum	47.54	34.70	37.65	.....	11.09	7.59
		7 Minimum	30.49	5.75	25.51	.....	4.60	1.19
	Hornig	1	33.53	30.29	29.99	.31	5.88	.....
	Von Klenze	1	35.18	27.99	32.23	.....	4.60	.....
	Lindt	5 Average	33.00	30.50	30.44	.....	4.17	.....
		5 Maximum	37.44	33.37	37.51	.....	4.95	.....
		5 Minimum	24.17	28.54	30.34	.....	3.38	.....
Engandine	....do	1	47.30	11.40	36.34	.....	4.96	.....

[1] Green cheese.

[2] Sugar, ash, etc.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Formaggini di Lecco.	Cornalba	2	61.00	19.20	16.37	.....	3.43	1.90
			16.66	41.50	35.80	.....	6.10	3.00
Frühstücks Käschen.	Bureau of Chemistry.	10 Average	49.93	25.93	19.43	.....	4.62	.....
		10 Maximum	59.95	33.88	24.82	.....	6.47	.....
		10 Minimum	39.40	16.96	15.63	.....	3.31	.....
Gammelost	Voelcker	1	42.44	3.36	42.12	9.85	2.22	.....
	Bureau of Chemistry.	4 Average	45.34	4.20	49.14	.....	1.49	.....
		4 Maximum	46.25	8.07	50.91	.....	1.76	.....
		4 Minimum	43.50	2.31	44.08	.....	1.18	.....
Gervais	Balland	4 Average	51.58	31.98	11.30	4.29	.60	.....
		4 Maximum	58.00	40.47	19.94	7.09	1.42	.....
		4 Minimum	44.70	26.85	7.20	2.13	.25	.....
	König	1	52.94	29.75	11.80	2.58	2.93	.....
	Richmond	1	33.80	57.79	7.90	.....	.50	.....
	Stutzer	1	44.84	36.73	15.48	.....	2.95	.76
	Bureau of Chemistry.	1	35.22	51.21	11.93	.....	2.21	.....
Gex	Balland	2	31.50	28.85	29.96	5.51	4.18	.....
			32.10	32.20	29.86	.34	5.50	.....
Gislev	Böggild	1	49.22	2.96	41.53	.....	.....	.....
Gloucester	Bell	1	35.75	28.35	31.10	.31	4.49	.....
	Blyth	1	21.40	25.40	48.10	.....	4.10	.....
	Chattaway	2	33.10	23.50	31.80	.....	5.00	.....
			37.40	28.10	28.30	.....	4.60	.....
	Griffiths	1	34.10	37.92	21.68	1.98	4.32	.....
	Hassall	1	32.52	29.94	31.70	.....	5.84	.....
	Jones	1	35.81	21.97	37.96	.....	4.25	.....
	Voelcker	13 Average	34.80	28.02	27.96	4.37	4.53	1.34
		13 Maximum	40.88	33.68	31.75	7.44	5.70	2.04
		13 Minimum	28.10	22.70	24.50	1.22	3.56	.85
Goats'-milk—French.	Balland	1	20.80	25.90	33.60	15.30	4.40	.....
	Lindet	1	64.80	9.20	17.10	.....	5.80	4.90
	Patrick (2)	1	17.73	46.64	27.90	.....	4.74	.....
Goats'-milk — Norwegian.	Werenskiold	8 Average	20.90	19.86	7.62	46.81	6.06	.....
		8 Maximum	26.53	32.68	10.63	58.07	6.57	.....
		8 Minimum	15.53	10.98	4.43	39.04	5.14	.....
Gorgonzola	Bell	1	31.85	27.88	34.34	1.35	4.58	2.11
	Chattaway	2	40.30	26.10	27.70	.....	5.30	.....
			33.90	26.70	25.80	.....	4.60	.....
	Duclaux	2	42.80	29.70	23.14	.....	4.36	2.21
			38.69	34.07	22.78	.....	4.46	2.64
	Hornig	1	36.72	33.69	25.67	.21	3.71	.....
	Von Klenze	1	26.81	35.29	33.80	.....	4.10	.....
	Lindet	1	41.50	29.00	19.70	.....	4.80	2.60
			34.41	37.52	26.75	.....	4.08	1.33
	Maggiora	3	32.43	34.08	25.94	.....	[1] 6.77	.99
			37.63	36.19	26.94	.....	[1] 10.46	.92
	Musso	7 Average	37.30	34.67	25.16	1.62	3.82	.....
		7 Maximum	47.10	39.32	28.51	2.00	4.63	.....
		7 Minimum	29.82	29.00	20.33	.91	3.13	.....
	Soxhlet	1	43.56	27.95	24.17	.....	4.32	.....
	Bureau of Chemistry.	1	33.72	33.60	28.39	.....	3.52	.....
			(German) 38.96	30.76	26.22	.....	3.84	.....
Gouda	Arnold	1	21.90	24.81	46.95	.....	6.32	.....
	Cribb	11 Average	54.79	9.02	25.94	.....	5.52	.....
		11 Maximum	60.17	18.37	34.22	.....	7.30	.....
		11 Minimum	50.46	1.64	22.05	.....	4.26	.....
	Mayer	1	38.80	31.20	24.40	.....	5.60	2.80
	Patrick (2)	1	35.23	29.40	27.01	.....	5.41	.....
	Vieth	1	42.58	16.18	37.43	.....	3.81	3.68
Gouda—American	Haecker	3 [2]	46.03	31.13	18.01	3.04	2.55	.....
			46.52	29.04	19.25	3.18	2.88	.....
			46.59	28.29	19.64	3.40	3.12	.....
	Bureau of Chemistry.	6 Average	38.11	24.50	29.58	.....	6.07	.....
		6 Maximum	42.31	30.72	35.32	.....	7.83	.....
		6 Minimum	31.04	15.05	26.41	.....	5.51	.....
Gruyère	Balland	9 Average	29.99	28.19	33.03	4.82	3.96	.....
		9 Maximum	33.10	33.40	37.80	7.40	4.70	.....
		9 Minimum	27.50	23.10	29.54	1.50	3.50	.....
	Benecke	1	40.61	26.59	26.18	1.94	4.68	2.10
	Chattaway	2	28.20	28.60	31.30	.....	4.70	.....
			35.70	31.80	28.70	.....	3.70	.....
	Duclaux	1	36.00	29.29	30.84	.....	3.87	.57
	Lindet	1	35.70	28.00	28.90	.....	3.50	.40

[1] Abnormally high ash content was due to a gypsum preparation with which the cheese was coated.
[2] Green cheese.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Gruyère	Lindt	2	34.57	29.12	32.51	.....	3.80	.....
			35.74	30.64	29.95	.....	3.67	.....
	Payen	2	40.00	24.00	31.50	1.50	3.00	.....
			32.05	28.40	33.75	.....	4.79	.....
Harz	Vieth	1	55.79	1.34	37.01	.....	5.86	4.16
	Vieth	3	50.19	1.64	27.72	[1] 14.80	5.65	.....
			52.49	1.83	22.43	[1] 18.00	5.25	4.12
			52.75	1.11	19.38	[1] 21.40	5.36	4.08
Hervé	Balland	1	37.50	23.93	20.86	7.71	10.00	.....
Ilha	Hoffmann	1	28.39	32.00	30.62	2.85	6.14	1.66
	Pereira	1	36.89	27.15	24.30	7.71	3.95	1.50
Incanestrato	Spica	14 Average	29.07	24.74	30.09	.....	9.46	5.04
		14 Maximum	32.48	37.48	38.66	.....	12.70	8.12
		14 Minimum	26.02	15.88	25.16	.....	4.58	.78
Isigny	Bureau of Chemistry.	9 Average	52.04	23.41	20.59	.....	3.97	.....
		9 Maximum	60.90	37.48	30.50	.....	4.83	.....
		9 Minimum	27.47	14.22	16.21	.....	2.71	.....
Kajmak	Zega	10 Average	31.55	55.79	6.25	2.01	4.50	3.07
		10 Maximum	36.03	63.82	8.73	3.20	8.38	7.36
		10 Minimum	23.97	50.16	4.94	.42	2.61	1.10
Kascaval	Maior	2	50.50	14.10	28.10	2.50	4.80	.....
			39.10	25.50	28.00	1.40	6.00	.....
Katschkawalj	Zega	16 Average	35.25	31.24	24.25	2.84	6.42	3.95
Koppen	Bureau of Chemistry.	4 Average	55.16	24.47	16.96	.....	3.56	.....
		4 Maximum	55.79	24.64	17.42	.....	3.84	.....
		4 Minimum	54.67	24.38	16.14	.....	2.98	.....
Krutt	Leutner	2	8.59	1.31	78.68	1.93	9.46	8.01
			10.14	1.45	69.74	.81	17.84	13.34
Laguiole	Balland	1	34.50	25.20	28.70	6.15	5.45	.....
Leicester	Griffiths	1	34.77	28.00	27.86	5.21	4.16	.....
	Voelcker	2	35.21	27.28	27.93	5.54	4.04	1.03
			32.89	29.28	29.06	4.42	4.35	1.21
Leyden	Mayer	1	46.90	11.00	35.90	1.00	5.20	1.40
	Bureau of Chemistry.	5 Average	40.58	13.48	37.77	.....	5.22	.....
		5 Maximum	43.30	14.50	39.30	.....	5.96	.....
		5 Minimum	35.35	11.20	34.90	.....	4.26	.....
Liederkranz	.....do	4 Average	55.12	24.45	16.78	.....	3.89	.....
		4 Maximum	56.74	25.50	18.25	.....	4.35	.....
		4 Minimum	54.10	23.60	15.76	.....	3.56	.....
Limburg—American	Arnold	4 Average	35.64	29.82	28.53	.....	5.98	.....
		4 Maximum	48.60	34.98	35.05	.....	6.69	.....
		4 Minimum	23.26	21.29	23.58	.....	4.82	.....
	Johnson	1	42.12	29.40	23.00	.38	5.10	3.51
	Bureau of Chemistry.	6 Average	46.35	28.26	21.62	.....	3.95	.....
		6 Maximum	49.41	30.33	23.99	.....	5.03	.....
		6 Minimum	41.12	27.72	20.17	.....	3.03	.....
Imported	.....do	5 Average	54.79	19.61	21.27	.....	5.17	.....
		5 Maximum	58.48	21.95	23.61	.....	5.50	.....
		5 Minimum	49.86	16.25	19.58	.....	4.39	.....
Livarot	Balland	1	33.80	21.95	31.76	8.05	4.44	.....
	Lindet	1	52.20	15.00	25.90	.....	4.40	2.90
Mainz Hand	Von Klenze	1	53.74	5.55	37.33	.....	3.38	.....
Maroilles	Lindet	1	40.30	33.50	20.20	.....	4.50	3.30
	Payen	1	40.07	28.73	23.31	.....	5.93	.....
Mascarpone	Fascetti	2	45.88	45.30	8.14	.....	.68	.....
			43.38	49.50	7.62	.....	.50	.....
Mont-d'Or	Balland	1	43.20	23.97	20.10	8.84	3.89	.....
	Lindet	1	58.70	9.70	25.30	.....	4.30	1.90
	Bureau of Chemistry.	1	41.26	33.05	21.12	.....	2.32	.....
Münster	Balland	2	45.40	25.90	16.86	6.88	4.96	.....
American	Lindet	1	37.50	29.83	18.17	9.75	4.75	.....
	Bureau of Chemistry.	1	52.40	24.40	15.50	.....	5.00	3.70
		2	33.63	31.60	28.65	.....	8.62	.....
American	.....do	1	36.83	33.80	24.63	.....	3.88	.....
			40.60	31.00	22.20	.....	4.63	.....
Mysost	Dahl	6 Average	23.57	16.26	8.88	44.84	4.76	.....
		6 Maximum	26.49	20.98	10.78	53.03	6.09	.....
		6 Minimum	18.58	9.63	6.79	30.75	3.28	.....
	Voelcker	1	24.21	20.80	9.06	41.01	4.92	.....
	Werenskiold	22 Average	29.43	4.08	7.66	53.24	5.75	.....
		22 Maximum	38.01	10.54	9.19	61.38	6.38	.....
		22 Minimum	24.37	.07	6.34	46.00	5.06	.....
	Bureau of Chemistry.	5 Average	14.41	25.70	10.91	.....	5.34	.....
		5 Maximum	26.56	34.51	13.97	.....	6.23	.....
		5 Minimum	10.05	18.22	9.06	.....	4.56	.....

[1] Caraway seed.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
Mysost—Continued.			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
American	Bureau of Chemistry.	5 Average	23.74	2.79	9.86	.....	5.77	.....
		5 Maximum	28.16	4.26	10.85	.....	6.34	.....
		5 Minimum	20.92	1.19	9.25	.....	5.09	.....
Neufchâtel	Balland	2	50.80	25.15	17.60	5.12	1.33	.....
			54.80	20.59	14.43	5.98	4.20	.....
	Blyth	1	37.90	41.30	23.10	.....	3.40	.....
	Von Klenze	1	51.72	23.99	20.73	.....	3.56	.....
	Martin	2	56.08	23.34	16.67	1.42	2.49	1.44
			57.83	21.00	17.00	1.32	2.85	1.90
	Payen	2	34.47	41.91	13.03	6.96	3.63	.....
			36.58	40.71	14.18	9.02	.51	.....
American	Bureau of Chemistry.	5 Average	52.05	23.51	19.33	.....	4.97	.....
		5 Maximum	60.45	34.87	23.28	.....	6.26	.....
		5 Minimum	36.64	16.25	16.08	.....	4.05	.....
	Arnold	1	37.45	34.60	24.04	.....	3.90	.....
	Johnson	1	57.25	22.30	15.03	2.94	2.48	1.42
	Bureau of Chemistry.	42 Average	59.22	18.17	21.30	.....	2.43	.....
		42 Maximum	70.46	33.65	28.84	.....	4.77	.....
		42 Minimum	42.17	1.14	16.08	.....	1.12	.....
	Currie	3 Average	50.33	26.09	19.91	[1]	.....	.....
		3 Maximum	53.52	29.90	20.75	.....	.....	.....
		3 Minimum	45.46	23.29	19.30	.....	.....	.....
Nögelost	Dahl	3	48.51	6.13	32.72	8.59	3.79	.....
			17.12	7.36	31.63	10.36	3.41	.....
			40.54	16.87	31.29	7.90	3.17	.....
	Voelcker	3	43.87	15.89	29.93	6.47	4.84	.....
			45.39	9.97	33.12	6.39	5.13	.....
			42.44	3.36	42.12	9.85	2.22	.....
Olivet	Balland	1	28.40	48.16	13.98	5.16	4.30	.....
Olmütz	Hornig	1	44.54	3.37	41.04	.16	10.89	.....
	Soxhlet	1	52.49	7.70	38.02	.....	1.79	.....
Parmesan	Arnold	1	23.01	12.49	55.85	.....	8.14	.....
	Chattaway	1	32.50	17.10	43.60	.....	6.20	.....
	Duclaux	2	30.09	26.04	38.42	.....	5.45	1.76
			32.56	21.75	42.27	.....	5.07	1.65
	Lindet	1	34.00	23.00	35.00	.....	5.20	1.70
	Manetti	8 Average	32.16	19.13	43.54	.....	6.29	.....
		8 Maximum	36.11	23.42	48.93	.....	7.18	.....
		8 Minimum	30.20	12.58	38.33	.....	5.20	.....
	Patrick (2)	1	35.39	19.72	35.55	.....	4.82	.....
	Payen	2	27.56	15.95	44.08	6.69	5.72	.....
			30.31	21.68	34.25	.....	7.09	.....
	Soxhlet	1	34.57	24.05	35.15	.....	6.23	.....
Formaggio	Bureau of Chemistry.	4 Average	16.95	22.71	49.39	.....	7.59	.....
		4 Maximum	32.00	24.37	56.70	.....	10.38	.....
		4 Minimum	12.67	19.70	33.94	.....	5.37	.....
Reggiano	.....do	6 Average	29.63	27.29	34.84	.....	4.76	.....
		6 Maximum	30.61	30.00	38.66	.....	5.02	.....
		6 Minimum	28.27	24.14	32.73	.....	4.63	.....
Pecorino	Sartori	4 Average	29.80	30.51	33.51	.....	6.24	4.95
		4 Maximum	32.90	31.30	35.59	.....	6.84	5.51
		4 Minimum	27.47	29.96	30.74	.....	5.31	4.34
Romano	Bureau of Chemistry.	15 Average	29.56	27.69	31.20	.....	8.66	.....
		15 Maximum	33.95	30.87	35.28	.....	9.74	.....
		15 Minimum	26.01	24.55	29.16	.....	7.00	.....
Petit Suisse	Lindet	1	54.60	35.00	7.30	.....	.60	.10
Pimiento (Cheddar)	Bureau of Chemistry.	6 Average	48.01	32.25	16.01	.....	1.91	.....
		6 Maximum	55.83	46.21	20.16	.....	2.49	.....
		6 Minimum	37.25	19.03	12.82	.....	1.56	.....
Pineapple	Clark	2	3.59	54.56	36.60	.....	5.25	.....
			5.20	46.46	43.28	.....	5.06	.....
	Johnson	4 Average	24.07	38.12	29.35	2.49	5.69	2.24
		4 Maximum	30.95	45.20	34.45	2.75	6.18	2.61
		4 Minimum	11.62	33.26	27.00	2.16	5.10	1.86
	Bureau of Chemistry.	1	20.61	40.64	31.13	4.63	.....	.....
Pont-l'Évêque	Arnold	1	44.57	21.80	30.36	.....	3.97	.....
	Balland	1	46.40	25.00	20.32	6.68	1.60	.....
	Lindet	1	51.00	23.10	17.80	.....	4.00	1.90
Pont-l'Évêque—American	Arnold	1	26.02	50.80	20.64	.....	2.54	.....
	Bureau of Chemistry.	2	37.46	32.68	25.90	.....	3.61	.....
			46.92	25.95	24.45	.....	2.83	.....

[1] Casein.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analyses.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Port du Salut	Balland	1	27.70	35.10	31.16	2.04	4.00	.....
	Duclaux	2	47.51	25.93	22.56	.....	4.00	1.90
			48.02	24.00	24.29	.....	3.69	1.56
	Lindet	1	38.10	24.50	24.80	.....	5.30	2.20
	Rollet	1	46.46	26.31	23.66	.....	3.67	1.31
	Bureau of Chemistry.	1	50.10	25.17	21.18	.....	2.91	.....
Potted—								
American Club House.	Weems	1	38.98	34.01	21.13	.....	1.49	.....
Imperial	do	1	30.63	33.10	26.88	.....	4.22	.....
Royal Paragon	do	1	32.85	31.52	27.74	.....	4.13	.....
Rabacal	Hoffmann	1	16.45	37.36	35.00	2.93	8.26	2.42
Rebbiola	Cornalba	2	46.56	25.55	19.99	.....	7.90	5.80
			45.36	30.56	20.21	.....	3.73	1.22
Reblochon	Lindet		53.20	20.50	19.30	.....	3.70	1.80
Reindeer milk	Werenskiold	1	27.70	43.11	23.79	2.97	2.43	.....
Ricotta	Sartori	1[3]	68.47	5.22	18.72	3.97	3.62	.....
Romadour	Hornig	2	56.60	17.05	18.76	.81	6.78	.....
			51.21	9.16	33.60	.02	6.01	.....
	Von Klenze	1	43.21	10.56	30.18	.....	6.10	.....
	Lindet	1	60.40	11.90	19.60	.....	5.60	3.90
	Patrick (2)	1	55.16	14.76	26.05	.....	5.47	.....
	Vieth	1	44.55	16.16	32.72	.....	6.57	5.80
Roquefort	Arnold	3	28.35	29.98	32.84	.....	8.82	.....
			28.87	33.70	28.82	.....	8.66	.....
			22.47	34.02	34.99	.....	8.24	.....
	Balland	1	28.90	38.30	25.16	3.00	4.64	.....
	Bell	1	32.26	34.38	27.16	1.32	4.88	.....
	Chattaway	1	29.60	30.30	28.30	.....	6.70	.....
	Hornig	1	36.93	31.23	25.79	.....	4.78	.....
	Johnson	1	39.28	29.53	22.62	1.77	6.80	5.27
	Von Klenze	1	38.94	34.14	21.92	.....	5.00	.....
	Lindet	1	36.90	29.50	20.50	.....	7.00	5.10
	Muter	1	21.56	35.96	32.24	.....	10.24	.....
	Patrick (2)	1	34.37	34.54	24.40	.....	6.16	.....
	Payen	2	26.53	32.31	31.69	.....	4.45	.....
			34.55	30.14	26.52	3.72	5.07	.....
	Sieber	2	23.54	40.13	27.00	.....	6.27	.....
			36.93	31.23	25.79	.....	4.78	.....
	Bureau of Chemistry.	12 Average	35.97	34.32	23.06	.....	6.33	.....
		12 Maximum	45.01[1]	39.61	29.10	.....	8.22	.....
		12 Minimum	26.43	26.85	19.93	.....	5.05	.....
German	Bureau of Chemistry.	5 Average	35.40	34.78	21.11	.....	6.53	.....
		5 Maximum	41.27	40.37	22.97	.....	8.22	.....
		5 Minimum	32.22	31.32	18.36	.....	4.29	.....
	Currie	7 Average	38.69	32.31	21.39[2]	.....	6.14	.....
		7 Maximum	40.10	33.53	23.06	.....	6.81	.....
		7 Minimum	37.49	31.50	19.14	.....	5.18	.....
	Sartori	3[4]	43.80	36.46	8.66	10.36	.72	.....
			42.48	31.64	13.61	11.49	.78	.....
			43.29	31.90	12.94	10.75	1.02	.....
Saloio	Hoffmann	1	76.25	1.78	11.37	5.28	5.32	2.49
	Pereira	2	54.37	25.84	13.63	2.96	3.20	2.04
			45.81	27.80	15.16	5.97	5.26	3.17
Sapsago	Arnold	1	13.30	15.52	57.59	.....	13.57	.....
	Benecke	1	47.02	6.60	37.06	.....	10.10	7.53
	Von Klenze	1	38.17	12.27	45.73	.....	3.83	.....
	Bureau of Chemistry.	1	47.75	2.00	41.66	.....	11.87	.....
Savoy	Balland	2	52.40	5.90	28.84	9.38	3.48	.....
			49.70	6.45	27.32	12.53	4.00	.....
Schloss, American	Bureau of Chemistry.	4 Average	48.34	26.35	21.31	.....	3.79	.....
		4 Maximum	56.17	30.07	24.44	.....	4.62	.....
		4 Minimum	40.83	22.47	16.08	.....	2.84	.....
Septmoncel	Balland	1	28.20	31.25	32.06	3.99	4.50	.....
Serra da Estrella	Büttner	5 Average	43.58	27.69	22.02	2.69	4.00	.....
		5 Maximum	47.98	34.56	24.03	6.13	4.35	.....
		5 Minimum	35.22	19.70	20.40	1.55	3.51	.....
	Hoffmann	1	31.87	40.05	22.18	2.24	3.66	.89

[1] Packed in jars. The highest water content was 39.21 per cent.
[2] Casein.
[3] From cows' milk.
[4] From sheep's milk.

Analyses of cheese—Continued.

Variety.	Authority.	Number of analysis.	Water.	Fat.	Proteids, amids, etc.	Milk sugar, lactic acid, etc.	Total ash.	Salt in ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
.....	Pereira.....	12 Average.....	39.34	27.93	23.48	3.93	5.79	2.57
		12 Maximum...	50.07	37.93	32.10	6.78	8.96	5.26
		12 Minimum....	24.38	19.30	17.83	.78	3.23	.94
Servian.....	Zega.....	14 Average.....	53.99	19.30	21.32	2.63	3.30	1.86
		14 Maximum...	68.84	32.20	32.37	5.12	4.81	3.13
		14 Minimum....	42.10	7.77	14.66	.85	2.40	.93
Spalen.....	Benecke.....	1.....	28.14	33.69	30.78	2.55	7.38	4.46
Stilton.....	Chattaway.....	3.....	19.40	42.20	21.10	.....	2.60	.....
			21.20	45.80	26.30	.....	2.90	.....
			25.00	34.60	28.40	.....	4.10	.....
	Griffiths.....	1.....	31.22	37.24	24.28	3.40	3.86	.....
	Hassall.....	1.....	31.37	36.58	27.66	.....	4.39	.....
	Muter.....	1.....	28.60	30.70	35.60	1.08	4.02	.75
	Patrick (2).....	1.....	32.97	39.03	23.19	.....	3.24	.....
	Voelcker.....	2.....	32.18	37.36	24.31	2.22	3.93	.89
			20.27	43.98	33.55	.....	2.20	.29
	Bureau of Chemistry.	1.....	33.57	31.19	28.96	.....	3.00	.....
Swiss—American....	Arnold.....	1.....	38.51	24.84	32.02	.....	4.70	.....
	Haecker.....	3.....	41.43	29.93	22.13	2.90	3.34	.....
			35.91	33.21	24.82	3.32	3.06	.....
			38.40	32.40	22.88	3.24	3.48	.....
	Johnson.....	1.....	33.79	33.25	26.12	1.77	5.07	1.85
	Bureau of Chemistry.	3.....	34.28	32.60	27.55	.....	4.16	.....
			34.77	34.05	28.67	.....	4.21	.....
			33.77	31.67	26.19	.....	4.06	.....
Imported.....	.....do.....	6 Average.....	33.91	30.61	29.22	.....	4.16	.....
		6 Maximum....	34.54	31.86	30.42	.....	4.91	.....
		6 Minimum.....	33.43	28.20	28.20	.....	3.88	.....
Swiss—Russian.....	Kalantarow.....	5 Average.....	32.74	32.26	24.85	4.43	5.78	2.67
		5 Maximum....	35.44	37.20	28.81	6.90	7.44	4.78
		5 Minimum.....	29.80	28.97	20.57	.57	4.36	1.45
Swiss—Swedish.....	Dahl.....	3.....	29.34	36.44	23.20	6.11	4.78	.....
			38.64	29.13	23.21	4.36	4.39	.....
			36.02	32.05	24.76	4.59	2.39	.....
Tessel.....	Mayer.....	1.....	54.40	18.30	20.10	1.40	5.80	3.40
Thenay.....	Blin.....	1.....	30.14	15.00	18.12	.....	6.10	4.80
Topfen.....	König.....	1.....	72.44	6.22	16.91	3.07	1.36	.....
	Rubner.....	1.....	60.27	7.33	24.84	3.54	4.02	.....
Trappist.....	Adametz.....	1.....	45.90	26.10	23.30	.....	4.00	.....
Troyes.....	Lindet.....	1.....	58.70	18.60	14.60	.....	4.80	3.70
Vacherin.....	Benecke.....	1.....	54.02	23.74	18.98	2.04	3.08	1.77
	Lindt.....	1.....	45.87	27.21	25.29	.....	1.63	.....
Vendôme.....	Fallot.....	6 Average.....	48.69	20.90	27.97	.....	4.43	2.79
		6 Maximum....	56.33	30.61	45.52	.....	5.58	3.68
		6 Minimum.....	29.63	10.80	17.74	.....	3.10	2.08
Viterbo.....	Sartori.....	1.....	28.50	30.93	34.19	.....	6.38	5.03
Vorarlberg.....	Eugling.....	9 Average.....	42.99	17.02	31.19	3.79	4.94	.....
		9 Maximum....	56.85	31.99	40.11	7.21	6.89	.....
		9 Minimum.....	32.92	2.82	25.65	1.81	3.79	.....
	Von Klenze.....	2.....	56.61	4.48	36.42	.....	2.49	.....
			50.58	4.56	42.37	.....	2.49	.....
			31.97	29.08	27.43	7.16	4.36	.72
Warwickshire.....	Voelcker.....	3.....	33.61	30.04	29.70	1.95	5.60	2.78
			33.53	30.89	28.19	2.84	4.55	1.12
Wensleydale.....	Chattaway.....	1.....	28.30	33.30	27.20	.....	3.70	.....
Wiltshire.....	Griffiths.....	1.....	37.23	27.82	26.52	3.88	4.55	.....
	Jones.....	1.....	36.34	28.00	31.12	.....	4.41	.....
			31.44	28.71	29.00	3.60	4.25	1.03
	Voelcker.....	3.....	39.22	19.26	34.22	2.28	5.02	.60
			40.07	25.55	26.81	2.24	5.33	1.41
Yogurt—American...	Bureau of Chemistry.	2.....	52.61	26.54	16.59	.....	2.12	.....
			43.19	33.90	18.44	.....	1.90	.....
Ziger.....	Eugling.....	3.....	68.51	3.15	22.13	3.97	2.31	.....
			74.74	4.33	14.99	3.93	2.02	.....
			68.47	5.22	18.72	3.97	3.62	.....
	Von Klenze.....	1.....	31.00	3.48	64.62	.....	.90	.....

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L. O. HOWARD, Chief

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THE SWEET-POTATO LEAF-FOLDER.

By THOS. H. JONES,[1] *Entomological Assistant, Truck-Crop Insect Investigations.*

[With a complementary report regarding spraying experiments for its control, conducted in southern Texas by M. M. High.]

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INTRODUCTION.

The larva of *Pilocrocis tripunctata* Fab. (fig. 1 *c*, *d*), a member of the lepidopterous family Pyralidæ, was noted first as an enemy of sweet potatoes in Louisiana by the writer while cooperating with the Louisiana Experiment Stations in the fall of 1914. Since that time the species has been kept under observation at Baton Rouge, La., and has been noted also in Plaquemines and Tangipahoa Parishes.

The species, which may be called the "sweet-potato leaf folder" because of the habits of the larva, has not been observed as yet in destructive numbers in Louisiana; but it has been reported by Mr. M. M. High, of the Bureau of Entomology, as very injurious to the sweet potato near Brownsville, Tex., where he conducted control experiments with poisons during the fall of 1916. As it is possible that this pest may become an important enemy of sweet potatoes in the Southern States, it seems advisable to publish the results concerning its biology and the results of Mr. High's control experiments.[2]

[1] The author wishes to acknowledge the issistance of C. E. Smith and J. L. E. Lauderdale in the studies on the history and habits.

[2] Besides the complementary report by Mr. High, this bulletin includes notes made by him regarding the life history, habits, and enemies of the species in southern Texas. Especially because development under conditions existing in southern Texas may differ from that under conditions at Baton Rouge, statements taken from Mt. High's notes are credited to him. All other observations were made at Baton Rogue.

HISTORY, DISTRIBUTION, AND SYNONYMY.

The only published record regarding injury by this species appeared in 1915, when the writer mentioned the occurrence of the larva on sweet potato in Porto Rico (6).[1] It was described first as

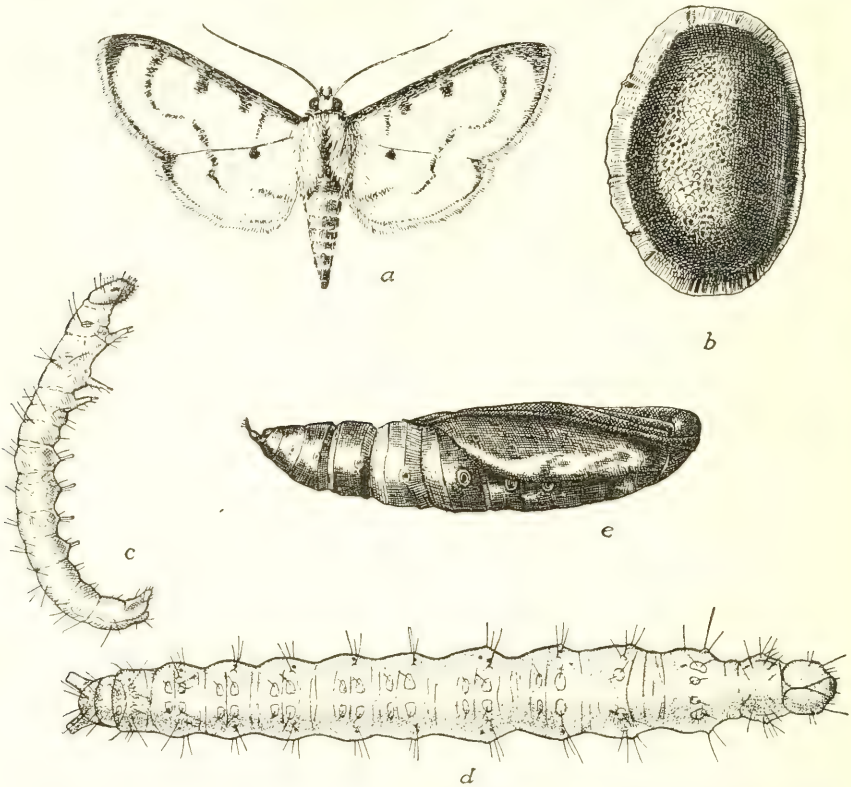

FIG. 1.—The sweet-potato leaf-folder (*Pilocrocis tripunctata*): *a*, Moth; *b*, egg; *c*, early stage of larva, from side; *d*, ventral view of larva; *e*, side view of pupa. All enlarged; *b*, highly magnified. (Original.)

Phalaena tripunctata by Fabricius in 1794 from material from the Central American Islands (1). Guénée recorded it (as *Botys cubanalis* Gn.) from Cuba (2), and Dyar listed it from Florida, Texas, and the West Indies (5).

Specimens from the following-named localities and now in the National Museum have been identified by Mr. August Busck: Kerville, Victoria, and San Antonio, Tex.; Mexico; Costa Rica; Jamaica, Cuba, and Grenada, West Indies. The addition of Baton Rouge, La., and Brownsville, Tex., completes the list of known localities where the species occurs.

[1] Figures in parentheses refer to "Literature cited," p. 12.

The following synonymy is recorded:

Phalaena tripunctata Fabr. 1794.
Botys cubanalis Guén. 1854.
Botys memmialis (F.) Walker. 1859.
Pilocrocis tripunctata Fabr. (Hampson). 1898.

DESCRIPTION OF STAGES.

THE EGG.

(Fig. 1, *b*.)

Thin, scalelike, with delicate walls, reticulated on upper surface; more or less regularly elliptical in outline, especially when laid singly. Being very plastic, the eggs vary considerably in shape. When laid the egg is at first colorless, practically transparent, and later the developing embryo can be seen plainly within. Measurements of 10 eggs that had been deposited singly: Average length, 1.06 mm., average width, 0.79 mm.

THE FIRST LARVA STAGE.

Of a number of larvæ examined, none of which was more than 24 hours old, the smallest measured about 1.5 mm. in length. The width of the head shield of all these individuals was very constant, about 0.25 mm.

Newly hatched larvæ are opaque, colorless, except for the dark, reddish-brown ocelli and the mouth parts, which are tinged faintly with brown. The body is cylindrical in shape, the surface smooth, glistening, with the setæ arising from colorless tubercles. In these newly hatched larvæ the head and legs are comparatively large, noticeably out of proportion to the rest of the body. After emergence from the eggs, however, the larvæ begin to increase rapidly in size, and this lack of proportion is soon lost. When the larvæ begin to feed the chlorophyll taken into their bodies imparts to them a greenish tinge.

LATER LARVA STAGES.

(Fig. 1, *c*, *d*; fig. 2, *a*, *b*.)

During the succeeding instars the shape of the larva remains cylindrical, the surface smooth and glistening. *In the third and subsequent instars tubercle ii of segments 3 and 4*[1] *is usually conspicuous because of its brownish or blackish color.* Sometimes, however, especially on segment 4, the tubercle is not dark.

When at rest the full-grown larva measures, immediately after feeding, about 27 mm. in length and 5 mm. in width. Measurements of the width of the head shields of 10 individuals gave an average of 1.81 mm., ranging from 1.75 mm. to 1.88 mm. The general color of the larva is bluish green. The head (fig. 4) is pale yellow, and the ocelli, tips of the antennæ, mouth parts, and claws of the true legs are brown.

THE PUPA.

(Fig. 1, *e*; fig. 2, *c*.)

The pupa is dark brown in color, somewhat lighter toward the posterior end. The surface is smooth, that of the abdominal segments dull and the remainder glistening. Eight bristles, curled at their tips, occur at the end of the cremaster.

Five pupæ averaged 15 mm. in length and 4 mm. in width at the widest point.

[1] The head is considered as segment 1, the prothorax as segment 2, and the others in succession.

THE ADULT.

(Fig. 1, *a*; fig. 3.)

The general color of the upper surface of the body and wings of the moth is light yellow, the wings iridescent. A dark grayish-brown band begins at the humeral angle of the forewing, from which it extends to the eye, and continues along the costal and outer margins of this wing and the outer margin of the hind wing. On either wing this band is widest at the apex. Inside the band and about one-sixteenth of an inch from it a wavy line of the same color

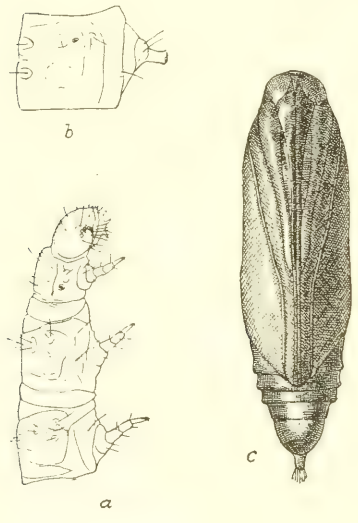

FIG. 2.—The sweetpotato leaf-folder: *a*, First three joints of larva, showing legs and arrangement of spiracles and spiracular tubercles; *b*, lateral view of a ventral segment; *c*, pupa, ventral view. All greatly enlarged. (Original.)

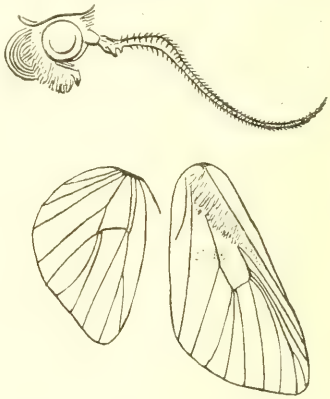

FIG. 3.—Wing venation and lateral view of head and antenna of a related species, *Pilocrocis ramentalis*, to show characters of genus. (Hampson.)

crosses both wings. Two black spots occur on the forewing, near the costal margin. The outer and larger one is near the middle of the margin and the smaller one about halfway between this and the base of the wing. A short, wavy, dark grayish-brown line occurs just inside this small black spot, extending backward from the band on the costal margin to a point about halfway across the wing. There is also a small black spot on the hind wing, near the costal margin and about halfway between the base of the wing and the wavy line previously noted. The markings are shown in figure 1, *a*.

The underside of the wings is lighter in color than are above, but have the same iridescent reflection with indications of the markings of the upper surface.

The ventral surface of the thorax and abdomen is white. The antennæ are light yellowish brown, and the legs white, except that the anterior surfaces of the first pair are for the most part of a dark grayish brown.

In the male the abdomen tapers more gradually to the posterior end than is the case in the female. The upper surface of the thorax also presents a more hairy appearance in the male, owing to the longer hairs of the tegulæ or lappets. With a lens a third point of difference is seen in the short bristles present on the underside of the basal portion of the antennæ of the male. These do not occur on the antennæ of the female.

Measurements of the wing expanse of 11 reared females gave an average of 27 mm., ranging from 25 mm. to 29 mm. The wing expanse of 7 reared males ranged from 25 mm. to 27 mm.

FOOD PLANTS.

In addition to the sweet potato as a food plant, moths have been reared from larvæ found feeding on uncultivated plants of the genus Ipomoea, to which the sweet potato belongs. It seems probable that some species of this genus, known under the common names of "bindweed," "wild sweet potato," and "wild morning-glory," are the natural larval food plants, and that the larvæ will feed on any of the numerous species of Ipomoea, in which genus are included a number of ornamental vines.

SEASONAL HISTORY AND HABITS.

OVIPOSITION.

Eggs have not been observed in the field at Baton Rouge, but the females, after feeding from pieces of sponge moistened in sweetened water, oviposited freely on sweet-potato plants in cages.

The eggs, which are securely fastened to the leaf, were placed on the underside, the areas alongside the leaf veins being a favorite location; Mr. High, however, from observations made in Texas, noted that apparently the eggs are deposited indiscriminately on either side of the leaf. Eggs are sometimes placed singly but as many as five have been noted in a group, their edges overlapping, although in no regular arrangement.

INCUBATION.

Eggs laid in the insectary at Baton Rouge on July 29 and 30 hatched on August 2 and 3, respectively. The period of incubation was, therefore, under these conditions, four days. The averages of the daily maximum and minimum temperatures for the insectary from July 29 to August 3, inclusive, were 92.5° and 74.0° F.

HABITS OF THE LARVA.

In the field the larvæ are found between separate leaves or portions of the same leaf which have been fastened together to form "shelters," each of which usually protects one larva. The larva constructs its shelter by spinning threads of silk from side to side across a portion of a leaf near the edge, each strand being shortened as the preceding strands contract in drying, until finally the edge of the leaf is

drawn completely over and fastened down with the shorter bands of silk. The precise process of this species has not been noted in detail. Mr. High has found that the larva when young eats small irregular holes in the leaf, but later consumes more of the leaf as the larva increases in size, in extreme cases devouring all of the leaf except the larger veins and midrib. The shelters and the injury to the leaves, due to the feeding of the larvæ, are shown in figure 4.

FIG. 4.—Sweet-potato vine showing work of sweet-potato leaf-folder. (Original.)

When the shelters are broken open and the larvæ disturbed they throw themselves rapidly about, much as a fish does when removed from water, and this violent action soon results in their reaching the surface of the soil, where, if there is a heavy growth of vines, they are difficult to find.

LENGTH OF LARVA STAGES.

The number of molts the larvæ undergo may vary, but the usual number apparently is 6. In the insectary at Baton Rouge during 1916 2 lots of adults were reared from eggs that had been laid by

moths kept in confinement. The first lot were from larvæ that issued on June 21. Eight of these spent 13 days in the larva stages, and 2 pupated 14 days after issuing from the egg. The averages of the daily maximum and minimum temperatures for this period, taken from a self-registering thermograph, were 95.3° and 72.6° F., respectively.

The second lot of larvæ were reared during August. They issued on August 3. Two pupated 13 days after issuing from the egg, while two required 14 days, one 15 days, and six 16 days for the larva stages. For this period the average of the daily maximum temperatures was 90° F. and the average of the daily minimum temperatures 72.8° F.

In the case of the larvæ reared during August observations were made to determine the length of time required for the various instars. Because of the fact that after the first five molts the larva usually devours all of the cast skins, with the exception of the tougher portion from the head, it is rather difficult to determine the exact time of molting, especially in the early stages. The time spent in each of the 6 instars was, however, ascertained from 7 larvæ. With two exceptions the periods were as follows: First instar, 3 days; 2d, 3d, 4th, and 5th instars, 2 days each; 6th instar, 5 days. One larva spent 3 days in the second instar and another only 4 days in the sixth instar.

PREPARATION FOR PUPATION.

After completing its growth the larva ceases feeding and constructs a cocoon, within which it transforms later to the pupa. During the period intervening between the time when the last food is taken and the time of pupation the larva undergoes a gradual change; it becomes shorter, the bluish-green color disappears, and the larva becomes sluggish.

In the insectary during July and August the time required in preparation for pupation was, with few exceptions, two days. In a few cases three days were required. Under the heading "Hibernation" the length of time passed in preparation for pupation by individuals that complete their larval growth later in the season is given.

PUPATION.

In the field and in the insectary pupæ normally are found in loose cocoons within the shelters made by the larvae. Larvae developing after the latter part of August sometimes construct in confinement a somewhat different type of cocoon, which will be discussed later.

The pupa period occupied from 6 to 9 days in the insectary during July and August. During September, 1915, two individuals

kept outdoors in glass jars transformed to moths 7 days after becoming pupæ.

HIBERNATION.

This species, judging by analogy, passes the winter months as a larva. The behavior of individuals kept in the insectary, however, should be mentioned in this connection. Larvæ collected in the field August 23, October 16, and November 1, 1915, the last date being the latest when larvæ were taken outdoors in 1915, were placed in the insectary. Here they constructed above the surface of the soil rather tough, brownish, silken cocoons of a more substantial nature than those from which moths issued during the summer months. Examination of some of these cocoons, made as late as December 11, showed that they contained inactive larvæ. The exact date when pupæ were formed was not ascertained, but moths began to issue as early as May 10. From observation it would appear that eggs are first deposited outdoors about this time.

On October 10, 1916, larvæ were found, in cocoons similar to those mentioned above, in a field of sweet potatoes at Baton Rouge. These cocoons were found at the surface of the soil, in portions of old, dead, sweet-potato leaves.

In southern Texas, according to Mr. High, the last generation doubtless passes the winter in the last larva instar and pupates in the spring or late in the winter. He has observed that the mature larva of this generation spins a cocoon of strong silk during the first half of November and remains in a quiescent state until ready to pupate. The cocoons usually are covered with soil or leaves, although any material the larva is able to draw together may be utilized. Where no such material is available it will make the cocoon entirely of silk.

THE LIFE CYCLE.

The minimum time required for the various stages in the insectary at Baton Rouge was as follows:

	Days.
Egg stage	4
Larva stages	13
Prepupa stage	2
Pupa stage	6
Total life cycle	25

In June larvæ were found in a cage 7 days after newly emerged moths had been placed therein, so that it appears that moths may begin egg-laying within at least 3 days after they have issued. This would give a minimum total of 26 days for the life cycle.

Under normal outdoor conditions the time necessary for the life cycle probably would be somewhat longer than that required in the

insectary, since the temperature of the insectary is higher than the outdoor temperature. In outdoor cages moths began to issue on August 24 and August 26, 28 and 29 days after the eggs had been deposited.

It appears that during the summer months the life cycle requires about five weeks in the field at Baton Rouge. Early in September, moths, pupæ, and larvæ in all stages of development were found on sweet-potato vines. There are probably four, and possibly five, generations during the season in the latitude of Baton Rouge.

NATURAL ENEMIES.

A tachina fly (*Exorista pyste* Walk.) and an ichneumon fly which Mr. A. B. Gahan, of the Bureau of Entomology, has pronounced to be a new species of the genus Bassus, have been reared from collections of larvæ made in the field at Baton Rouge, indicating that they are parasites of the sweet-potato leaf-folder. Adults of the spined soldier bug (*Podisus maculiventris* Say) have been observed with larvæ impaled on their beaks.

Mr. High observed a predacious enemy of the larva in the "jackdaw," or boat-tailed grackle (*Megaquiscalus major macrourus* Swainson). The following notes are from his records.

"This bird winters in southern Texas by millions and feeds on a number of insects that attack truck crops and particularly on larvæ. * * * observed it first feeding on the cabbage looper (*Autographa brassicæ* Riley) in 1913, two days after cabbage had been sprayed with an arsenical.

"Some species of larvæ after being poisoned have a habit of crawling to the top leaves of the plant upon which they are feeding before dying, and here they fall easy prey to the grackle. The poison apparently does not seriously affect the birds, since none have been found dead in the vicinity of sprayed crops."

THE SWEET-POTATO LEAF-FOLDER IN SOUTHERN TEXAS.[1]

The sweet-potato leaf-folder (*Pilocrocis tripunctata* Fab.) was first observed by the writer in southern Texas September 17, 1916, when larvæ were found sparingly on a plat of sweet potato at Brownsville, Tex. On September 29 the larvæ were observed at work in another field near Brownsville, and by this time were more numerous in the plat where first they were found. At this time a sudden change in the weather accompanied by hard showers somewhat reduced their numbers.

By the middle of October the caterpillars had become so abundant that it was found advisable to spray immediately. Later a

[1] Reported by M. M. High, Entomological Assistant, Bureau of Entomology, United States Department of Agriculture.

second application was made. The results of these treatments are recorded in this report.

SPRAYING EXPERIMENTS.

On October 19 some sweet potatoes at Brownsville were sprayed for the sweet-potato leaf-folder with arsenate of lead at the rate of 1 pound (powder) to 50 gallons of water. At the time the spray was applied the infestation was localized in spots, mainly on one side of the plat. On the following night a shower washed a considerable amount of the poison from the vines. An examination October 22 showed that somewhat more than one-half of the larvæ were still feeding actively and did not appear to be poisoned. By October 25 the living larvæ had decreased to about 25 per cent of the original number, though it appeared that birds were partially responsible for the decrease.

Afterwards few larvæ were found up to the first few days of November, when they reappeared in large numbers and dozens could be collected in a very small space.

November 9 the sweet-potato patch was divided into three plats and sprayed with lead arsenate and zinc arsenite at different strengths. On account of the matting of the vines it was impossible to ascertain the number of larvæ by count on any one plant, so that the number was estimated over a given space both before and after spraying.

Plat No. 1 was sprayed with lead arsenate: 2 pounds (powder) to 50 gallons of water. The powder was first converted to paste and the remainder of the water was added. The spray was applied early in the afternoon, when the foliage was perfectly dry and a fairly uniform coating was secured. Particular care was taken to coat at least one side of the foliage thoroughly.

Plat No. 2 was sprayed immediately with lead arsenate at the rate of 1 pound (powder) to 50 gallons of water. This was applied in the same manner as in plat No. 1, but the spray seemed to spread more uniformly over the leaves than did the heavier dosage.

Plat No. 3 was sprayed with zinc arsenite: 1 pound (powder) to 40 gallons of water in which 12 pounds of cactus, to increase adhesiveness, had been placed 20 hours before. The solid cactus detritus was thrown out and the zinc arsenite added. This spray adhered better to the foliage than did either of the other sprays, though the whitening of the foliage was less definite than in plat No. 1, and hardly as much so as in plat No. 2.

On November 11 an examination showed that in plat No. 1 the leaves of the potato were scorched slightly, although not enough to cause serious damage. It was estimated that about 94 per cent of the larvæ had been destroyed or were past feeding. In plat No. 2

the mortality ranged from 93 to 95 per cent; in plat No. 3 mortality was a fraction higher, about 95 to 96 per cent.

All the plats were sprayed with a hand sprayer holding about 5 gallons of spray mixture, and probably a little more thoroughly than would be done on a large scale by inexperienced help. When potatoes are planted on soils with high nitrogen content, the foliage is usually heavy, requiring careful manipulation to secure thorough distribution of the spray mixture.

SUMMARY OF SPRAYING EXPERIMENTS.

The foregoing experiments demonstrate that the larvæ of the sweet-potato leaf-folder (*Pilocrocis tripunctata* Fab.) can be killed readily by timely applications of arsenical sprays. Either arsenate of lead or zinc arsenite at the rate of 1 or 2 pounds (powder) to 50 gallons of water will give favorable results. If the spraying is done early, one application may be sufficient, whereas if treatment is delayed until a large number of larvæ have spun cocoons, two or more applications may be necessary in order to effect complete control.

SUMMARY.

The caterpillar of a pyralid moth (*Pilocrocis tripunctata* Fab.) was very injurious to the foliage of sweet potato in southern Texas during the fall of 1916. No previous instance of injury appears to be recorded although the insect has long been known to inhabit the Gulf region. It occurs also in the West Indies and has been mentioned as feeding on the sweet potato in Porto Rico.

The various stages of this insect, which, because of the habits of the larva, has been given the name of "the sweet-potato leaf-folder," have been described from life-history studies carried on at Baton Rouge, La.

The minimum length of time required for the life cycle in the insectary at Baton Rouge, La., was found to be about 26 days. In the field there are probably 4, and possibly 5, generations a year in the latitude of Baton Rouge. The winter months apparently are spent in the last larva stage within a cocoon at or near the surface of the soil.

Two parasitic flies have been reared from the larvæ, and the spined soldier-bug has been found to be predacious upon the larvæ. In Texas the "jackdaw" or boat-tailed grackle feeds upon them.

Experiments conducted by the Bureau of Entomology indicate that the larvæ can be killed readily by spraying the foliage with either arsenate of lead or arsenite of zinc at the rate of 1 or 2 pounds (powder) to 50 gallons of water.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 610

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. ▼ Dec. 7, 1917

FISH MEAL AS A FEED FOR SWINE.[1]

By FRANK G. ASHBROOK, *Junior Animal Husbandman, Animal Husbandry Division.*

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INTRODUCTION.

Heretofore feeds and labor have been so abundant and have been available at such moderate prices that close calculation in their use has been unnecessary. The present war has caused the American farmer to make a closer study of the economics of the national feed situation than ever before. If a large part of the corn, wheat, barley, and similar carbonaceous grains must be saved for human consumption, then farmers who raise and fatten live stock will have to practice stricter economy in their feeding operations.

The hog is a heavy and promiscuous feeder. He is not a ranger and does not thrive on pasture alone. The grain fed to swine, however, can be reduced greatly by making wider use of nitrogenous feeds. Since the feeding stuffs of high protein content are already in great demand, now is the time to call upon the reserve supply of protein furnished by waste fish and by the waste from fish-canning industries. Many years ago attention was called to the possibilities of fish meal as a feeding stuff, both in this country and abroad, and it is indeed surprising that its use as a feed for stock has not been fostered in this country.

[1] The fish meal used in these experiments was made under the direction of Dr. F. C. Weber, Chemist in Charge, Animal Physiological Chemical Laboratory, Bureau of Chemistry. Acknowledgment is here made for his interest and cooperation, which made the experiments with fish meal possible.

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Fish meal and fish scrap, or "pomace," are similar in composition, the former, however, being prepared for use as a feeding stuff and the latter as a fertilizer. In the manufacture of fertilizer the object is merely to produce a material that contains one or more of the following necessary constituents: Nitrogen, phosphate, or potash. In the case of fish meal, being a feed stuff, the material from which it is made must be fresh, wholesome, and nutritious, and greater care must be taken in the manufacture.

The Norwegian Government in 1892 conducted a series of feeding experiments with fish meal and obtained very favorable results. Since then the merits of fish meal have been more and more appreciated in Germany, especially as a feeding stuff for pigs. For some years prior to the present war Germany not only used up all it could produce, but took all that England and Norway had to offer. In the United States fish meal as a feeding stuff has been neglected in spite of the proof of its value.

USE OF FISH MEAL IN THE UNITED STATES.

The amount of fish meal used for feeding purposes in this country is so small compared with other materials used as feeding stuff that it is hardly worth mentioning. Although of great use as a fertilizer, the product is clearly of more value to the country as a feeding stuff. English experiments have shown that the oil, which in many samples of fish meal ranges from 7 to 10 per cent, is distinctly disadvantageous in preventing the manure from rotting in the soil and yielding up its nitrogen to the crop. The oil itself contributes nothing to the value of the manure and is simply wasted when applied to the land. There is every reason to favor the view that fish meal should not be spread on the land until it has been passed through the digestive apparatus of farm stock.

Very little has been done to bring the value of fish meal before the agriculturist in this country. It is to be regretted that the American farmer has not been brought to appreciate the true value of fish meal.

Probably one of the reasons for fish meal having been thus neglected is the impression that if it is used in the feeding of animals, their flesh will become tainted. This belief is entirely unwarranted, as shown by German, English, and American experiments, and will be pointed out later in connection with our own experiments. If, as reported, some farmers who have tried it have not found fish meal satisfactory as a feeding stuff, it is because they have not used it with understanding. Fish meal is very similar to packing-house tankage in composition and can be fed in exactly the same proportions. If moderate proportions are fed in combination with carbonaceous feeds, its efficiency as a feeding stuff soon will become apparent.

FEEDING EXPERIMENTS WITH PIGS.

Two feeding trials were conducted at the Bureau of Animal Industry Experimental Farm, Beltsville, Md., to determine the value of fish meal as a feed for pigs.

1. COMPARISON OF FISH MEAL AND TANKAGE AS SUPPLEMENTARY FEEDS.

The first experiment was conducted to determine the comparative values of fish meal and tankage as supplements in a ration for growing and fattening pigs. The pigs used in this work were grade Berkshires, averaging 52.3 pounds per head when the experiment started. They were as uniform in size, age, and breeding as it was possible to obtain.

The guaranteed analysis of the tankage was:

	Per cent.
Protein	60
Fat	8
Phosphoric acid	8
Crude fiber	3

The analysis of fish meal was:

Water	6.36
Fat	15.34
Protein (N × 6.25)	57.31
Ash	16.52
Undetermined	4.47

The feeding period was divided into two parts: First, a growing period of 112 days from weaning up to fattening age, starting January 19, 1915, and ending May 11, 1915; second, a fattening period of about one month, starting May 11, 1915, and ending June 8, 1915. The pigs at this date averaged a little more than 250 pounds and were sold. During the first period the pigs were divided into two lots of 8 and 4; during the second, or fattening, period they were divided into three lots of 4. Details and results of the feeding are given below.

RESULTS DURING THE GROWING PERIOD.

The pigs, which were all in good, thrifty, growing condition, were about 3 months of age at the beginning of the experiment, and in order to accustom them to their surroundings they were fed in dry lot from the time they were weaned until the experiment was begun. The pigs in both lots were so fed that all the feed, which was in the form of a thin slop, was cleaned up at each feeding, thereby insuring a sharp appetite at the next feeding time. There was no trouble whatever in getting the pigs to eat the ration containing fish meal.

Summary of results during growing period, Jan. 19, 1915, to May 11, 1915 (112 days).

Lot 1. Ration: 4 parts corn meal, 4 parts middlings, 1 part tankage:			
Duration of experiment	days		112
Pigs	number		8
Average first weight	pounds		51.37
Average final weight	do		191.50
Average gain per pig	do		140.13
Daily gain per pig	do		1.25
Total grain fed	do		4,060.5
Average grain eaten per pig daily	do		4.53
Grain per 100 pounds gain	do		362
Lot 2. Ration: 4 parts corn meal, 4 parts middlings, 1 part fish meal:			
Duration of experiment	days		112
Pigs	number		4
Average first weight	pounds		54.25
Average final weight	do		201.50
Average gain per pig	do		147.25
Daily gain per pig	do		1.31
Total grain fed	do		2,152.5
Average grain eaten per pig daily	do		4.80
Grain per 100 pounds gain	do		365

During the growing period Lot 2, fed corn meal, middlings, and fish meal, made a greater daily gain than Lot 1, receiving the tankage supplement. The lot receiving the fish-meal supplement consumed 122.3 pounds more feed and gained a total of 28.5 pounds more in weight than did an equal number of Lot 1 receiving tankage. At the close of the growing period the average weight of the pigs fed fish meal was 201.5 pounds and that for the pigs getting the tankage supplement was 191.5 pounds, a difference of 10 pounds. From observation no difference could be noted between the two lots with respect to growth or general development. This would indicate that one ration was not particularly superior to the other in meeting requirements for growth in pigs.

RESULTS DURING THE FINISHING PERIOD.

The same 12 pigs were used for the second period and were divided into three lots and fed as follows:

Lot 3, composed of the same 4 pigs as Lot 2 in the growing period, was continued on the same ration, namely, 4 parts of corn meal, 4 parts of middlings, and 1 part of fish meal.

Lot 4, composed of 4 pigs from Lot 1, was fed a ration of 9 parts of corn meal and 1 part of fish meal.

Lot 5, composed of the remaining 4 pigs from Lot 1, was fed a ration of 9 parts of corn meal and 1 part of tankage.

Many farmers feed the same ration for both the growing and fattening periods, and the intention was to carry out this scheme

with this lot of hogs in order to determine the advisability of the practice.

Summary of results during fattening period, May 11, 1915, to June 8, 1915 (28 days).

Lot 3. Ration: 4 parts corn meal, 4 parts middlings, 1 part fish meal.		
Duration of experiment	days	28
Pigs	number	4
Average first weight	pounds	201.5
Average final weight	do	255.25
Average gain per pig	do	53.75
Daily gain per pig	do	1.91
Total grain fed	do	903.00
Average grain eaten per pig daily	do	8.06
Grain per 100 pounds gain	do	421.00
Lot 4. Ration: 9 parts corn meal, 1 part fish meal.		
Duration of experiment	days	28
Pigs	number	4
Average first weight	pounds	191.5
Average final weight	do	251.75
Average gain per pig	do	60.25
Daily gain per pig	do	2.16
Total grain fed	do	956.00
Average grain eaten per pig daily	do	8.54
Grain per 100 pounds gain	do	393.00
Lot 5. Ration: 9 parts corn meal, 1 part tankage.		
Duration of experiment	days	28
Pigs	number	4
Average first weight	pounds	192.00
Average final weight	do	248.00
Average gain per pig	do	54.00
Daily gain per pig	do	2.00
Total grain fed	do	910.00
Average grain eaten per pig daily	do	8.13
Grain per 100 pounds gain	do	462.00

The lot fed corn meal, middlings, and fish meal during the finishing period did not consume as much feed as the lot fed corn meal and fish meal or the lot fed corn meal and tankage. The lot fed 9 parts of corn meal and 1 part of fish meal made a better showing than either of the other lots in the rate of gain and pounds of feed fed per 100 pounds gain.

2. FISH MEAL AS A SUPPLEMENT TO DRIED POTATO.

The second experiment was conducted primarily to determine the value of dried pressed potato in a ration for fattening hogs when supplemented by feeds rich in protein. The results show conclusively that fish meal is an outstanding protein supplement to feed along with potatoes.

This experiment was started September 12, 1916, and continued 56 days, ending November 7, 1916. Twelve high-grade Berkshire pigs between 5 and 6 months of age, averaging approximately 150 pounds in weight, were used in this work. Those selected were very uniform in age, quality, breeding, and weight. The pigs were taken off pasture and put in the dry lot a week before the experiment proper began. They were confined in a permanent hog house and arranged into 4 lots of 3 pigs each. The pens used for each lot measure 6 feet by 7½ feet, and have cork-brick floors. Attached to these pens are outside runs of concrete 7 feet by 39 feet. Prior to the experiment the pigs were fed a ration of 5 parts corn meal, 4 parts middlings, and 1 part tankage. The experimental rations were as follows:

Lot 1 (check lot), 6 parts corn meal, 1 part tankage.

Lot 2, 6 parts dried pressed potato, 1 part tankage.

Lot 3, 6 parts dried pressed potato, 1 part linseed oil meal (old process).

Lot 4, 6 parts dried pressed potato, 1 part fish meal.

Following are the analyses of the dried pressed potato rations as made by the Bureau of Chemistry, Department of Agriculture:

Analyses of dried pressed potato ration.

Ration.	Moisture.	Ash.	Ether extract.	Protein.	Crude fiber.	Nitrogen-free extract.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dried pressed potato and tankage	11.83	3.04	0.80	11.03	2.29	71.01
Dried pressed potato and oil meal	11.91	1.65	.67	5.96	2.98	76.83
Dried pressed potato and fish meal	10.96	4.04	2.87	13.09	1.85	67.19

The lots were fed three times daily (7 a. m., 11.30 a. m., and 4.30 p. m.). For each meal the feed for each lot was weighed and put into a bucket with enough water to make a thick slop. The feed was mixed with water one-half hour before feeding, so as to allow it to soak. Just after the feed was mixed live steam was turned into each bucket of feed for a few minutes to facilitate soaking. A fresh supply of water was given to the pigs about the middle of the forenoon. The hogs were weighed on the scales located inside the permanent hog house; the weighing was done about 9.30 a. m. Individual weights were taken for three consecutive days (one day previous to the beginning of the experiment and each of the first two days of the experiment). The average of the three weights was taken as the weight of the second day or the beginning of the experiment. Individual weights were taken every Tuesday thereafter until the conclusion of the experiment.

RESULTS OF THE FEEDING.

The pigs in all the lots ate well and regularly and not one of them went off feed during the test. Small quantities of feed were left in the troughs after feeding time, but this was due to the fact that the pigs were required to eat a little more than they conveniently could handle. Dried pressed potato is rather bulky, and it is difficult to determine the amount that will be cleaned up by the pigs at one feed. All the pigs in the experiment were fed 2 pounds of feed per head per day at the beginning of the test. This, of course, was a very small quantity for 150-pound pigs, but they were given this small portion at first because by gradually starting pigs on a feed the appetite is kept keen and the chances of going off feed are very much lessened. The pigs also are better enabled to cultivate an appetite for a new feed.

Summary of results, fattening period, September 12 to November 7, 1916 (56 days).

	Lot 1, 6 parts corn meal, 1 part tankage.	Lot 2, 6 parts dried pressed potato, 1 part tankage.	Lot 3, 6 parts dried pressed potato 1 part oil meal.	Lot 4, 6 parts dried pressed potato, 1 part fish meal.
Number of pigs	3	3	3	3
Average first weight.....pounds..	153.33	153.33	150.00	154.33
Average final weight.....do....	242	198.33	206.33	228.66
Average gain per pig.....do....	87.77	45.00	51.33	74.33
Average daily gain.....do....	1.57	.80	.91	1.32
Total grain fed.....do....	1,072	939	900.5	956.5
Pounds fed per 100 pounds gain.....do....	403	695	584	428
Daily feed per 100 pounds, live weight.....do....	3.23	3.16	2.93	2.91
Average daily feed.....do....	6.4	5.5	5.3	5.7

All the pigs were in good, thrifty, growing condition at the beginning, and were maintained in good condition and health during the progress of the experiment. A study of the table will show that Lot 1 (check) excelled all the other lots with respect to rate of gains, amount of feed consumed to produce 100 pounds of gain, and the average final weight. This lot of pigs was the largest and growthiest in the experiment. They were heavy feeders and returned good gains for the amount of feed consumed.

The lot receiving dried pressed potato and fish meal (Lot 4) was a very close second to the check lot. The figures, however, show greater advantages in favor of the check lot than one could detect with the eye. Both these lots maintained good condition throughout the experiment and carried a very high degree of finish. There was a difference of 13 pounds per hog in favor of the check lot at the close of the test. The pigs in Lot 4 were evidently as heavy feeders as those in the check lot, but it is impossible for pigs to consume

very large amounts of the dried pressed potato on account of the bulkiness of this feed. The pigs receiving dried pressed potato and fish meal consumed a daily ration of 5.7 pounds, made a daily gain of 1.32 pounds, and required 428 pounds of feed to produce 100 pounds of gain.

The pigs in Lot 3, receiving dried pressed potato and oil meal, consumed less feed than any other lot in the experiment. From this, one might infer that the ration was the least palatable and least efficient of any of the rations fed. This, however, is not true, because the pigs in Lot 2, receiving dried pressed potato and tankage, ate more feed than Lot 3, although they made smaller gains. This tends to prove that the potato ration containing oil meal is more efficient in producing gains than the potato ration containing tankage, although the pigs ate less of the potato and oil-meal feed. The pigs in Lot 3 had a higher degree of finish than the potato and tankage pigs (Lot 2), but they were not equal to the potato and fish-meal pigs in this respect. The pigs in Lot 3 consumed a daily ration of 5.3 pounds, made a daily gain of 0.91 pound, and required 584 pounds of feed to produce 100 pounds of gain.

The pigs in lot 2, which were fed dried pressed potato and tankage, consumed enough feed to put them in higher condition than they had at the close of the feeding test. The showing that these pigs made can not be called poor, but it is evident that tankage is not as efficient as a protein supplement to use with dried pressed potato as fish meal or even old-process linseed-oil meal. The pigs in lot 2 returned a smaller amount of gain for the amount of feed consumed than any other lot in the experiment. These pigs consumed an average daily ration of 5.5 pounds, made an average daily gain of 0.80 of a pound, and required 695 pounds of feed to put on 100 pounds of gain.

CARCASS TEST.

At the close of both these experiments the heaviest hog was selected from each lot and slaughtered on the farm to determine the quality of flesh and fat and the degree of finish. The carcasses were divided into regular meat cuts in as nearly uniform a manner as possible. The fresh pork from each hog was eaten by individuals who were ignorant of the feed that the hogs received, in order to test the flavor and cooking qualities of the meat. The lard fat was cut from the trimmings and rendered, as was also the fat from the carcass, and observations upon them were made. In no case was the meat reported as having a fishy odor or taste. If the carcass had been tainted from feeding fish meal, it would most certainly have been evident in the rendering of the lard, but such was not the case.

The results of this work, and also the successful use of fish meal as a feeding stuff in Germany, show that the belief that the consumption of this product taints the meat is unwarranted.

CONCLUSION.

Fish meal is a very effective supplement to a grain ration for pigs. The animals relish it and are extremely fond of it. Fish meal was superior to tankage in all comparisons, although the daily gains in all cases were exceptionally good. The pigs maintained a thrifty growth and were never off their feed during the entire feeding period. Fish meal does not impart a fishy flavor to the meat or lard in any way if fed in proper proportions with other feeds. Where fish meal can be obtained conveniently at a reasonable price and in suitable quantity, it has a very considerable value in pig feeding. When given a fair trial and used in proper proportions it should become one of the most popular as well as most remunerative protein supplements for pig feeding.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 611

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER December 10, 1917

WALNUT BLIGHT IN THE EASTERN UNITED STATES.

By S. M. McMURRAN,

Assistant Pathologist, Office of Fruit-Disease Investigations.

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IMPORTANCE OF THE DISEASE.

The growing of the Persian (English) walnut in the eastern half of the United States is receiving increasing attention and arousing the interest of many. Persian walnut trees, mainly seedlings, either isolated or in small groups or orchards, are by no means uncommon in the States east of Lake Michigan and the Wabash River below the latitude of New England. An indication of the number of such trees now growing in this part of the country was contained in an address by Prof. F. N. Fagan, of State College, Pa., delivered before the Northern Nut Growers' Association in 1915, in which the statement was made that as the result of a recent survey by that college the "location of some 1,500 or 2,000 bearing trees" had been ascertained in that State. While there has been no effort to make a similar survey in other Eastern States, so far as the writer is informed, his personal knowledge and that of associates in the Bureau of Plant Industry indicates practically the same proportion of Persian walnut trees in the States of New York, Delaware, New Jersey, and Maryland. Isolated trees are known in lower Connecticut, southern Michigan, Ohio, and Virginia. Several eastern nurseries are now spe-

NOTE.—This bulletin is intended particularly for all engaged in propagating Persian walnuts in those portions of the United States east of the Rocky Mountains. It is also of scientific interest to plant pathologists.

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cializing in the growing of young trees for general planting. These facts, together with the increasing volume of correspondence received by the Department of Agriculture relative to walnut diseases and the known occurrence of the walnut blight, or bacteriosis, in the eastern United States, make it desirable to publish at this time a résumé of the history of this disease and its present status in the section specified, to the end that difficulties and disappointments may be avoided.

Commercial walnut growing in the United States may be said to have had its origin on the Pacific coast. At present the principal production of Persian walnuts in this country is from a few counties in southern California, although within recent years there has been extensive planting in the San Joaquin Valley, the Sacramento Valley and adjacent valleys of northern California, and in the Willamette Valley of western Oregon. To a considerable extent this walnut is now being planted by amateurs and experimenters in other States, especially Arizona and New Mexico. As a result of this situation, systematic studies of the species and its varieties, its cultural requirements, diseases, and insect pests have largely been confined to the West, and except as analogies can be drawn there is little in agricultural literature that will be of assistance to a prospective grower in the eastern United States.

During the seasons of 1910, 1911, and 1914 specimens of diseased nuts were received by the Bureau of Plant Industry from points in Maryland, Louisiana, Pennsylvania, Virginia, and Delaware and determined by Mr. M. B. Waite, Pathologist in charge of the Office of Fruit-Disease Investigations, to be affected with the so-called walnut blight, or bacteriosis. During the summer of 1916 an effort was made by the writer to determine the extent of the occurrence and the seriousness of this trouble in the eastern United States, as it appeared to be the most serious disease with which the industry now has to contend in this part of the country. Blighted nuts were found at practically all points at which bearing walnut trees were examined, and reports from other sections indicate that the presence of this disease is more or less general in the entire eastern district.

HISTORY OF WALNUT BLIGHT.

In 1901 Pierce [1] reported a walnut disease due to a bacterium which had at that time become established in the seedling orchards of southern California. He stated that it was highly pathogenic on young nuts, leaves, and tender twigs and frequently caused serious

[1] Pierce, N. B. Walnut bacteriosis. *In* Bot. Gaz., v. 31, no. 4, p. 272–275. 1901.

loss of young nuts. His paper gives a number of the characteristics of the organism in pure culture, and his work has subsequently been corroborated by Clayton O. Smith, of the Whittier Station in California, and the writer, in the eastern United States. Pierce proposed the term "bacteriosis" as being a suggestive name for the disease, though by growers the malady is commonly known and spoken of as walnut blight, which may be considered its common name. The disease-producing organism is now known as *Bacterium juglandis* (Pierce) Erw. Smith.[1] Since the publication of Pierce's paper reports by other writers have appeared from time to time, the most valuable contribution being Bulletin No. 231 of the California Agricultural Experiment Station.[2] The work reported in this paper, which extended over a period of some years, largely confirmed Pierce's studies and greatly augmented the existing knowledge of the disease-producing organism and its relation to its host.

A brief quotation will serve to indicate the seriousness with which this disease is regarded on the Pacific coast and the gravity with which it should be considered by present and prospective growers elsewhere.

> This is by far the most important trouble affecting the walnut in California. So serious has been this disease that the loss of a large portion of the crop has in some cases been charged to this source, legislatures have made special appropriations for its investigation, and the growers have offered a large reward for a practical remedy.
>
> At the same time the losses directly attributable to blight have been extremely large. One significant fact in this connection is that while the walnut acreage in southern California has multiplied many times during the past decade (1902–1912), the total walnut crop has increased very little during this time.
>
> This loss or failure of the crop to increase has not been entirely attributable to blight, yet it has certainly been due to the disease much more than to any other one factor.[3]

Until a few years ago walnut bacteriosis had been definitely known to occur only on the Pacific coast and in New Zealand. In 1913 Waite[4] reported the disease as occurring in the Eastern States. He stated:

> The California walnut bacteriosis has turned up at various points in the East. The twig-blight form of this disease is also prevalent in various States. The walnut blight, or bacteriosis, is therefore to be figured with in planting the Persian walnut in the East. . . . It occurs in Texas and Louisiana, and I think we have it in or near Buffalo, N. Y., and in New Jersey, so if I were

[1] Smith, E. F. Bacteria in Relation to Plant Diseases, v. 1, p. 171. Washington, D. C. (Carnegie Inst., Washington, Pub. 27.)

[2] Smith, R. E., Smith, C. O., and Ramsey, H. J. Walnut culture in California. Walnut blight. Cal. Agr. Exp. Sta. Bul. 231, p. 113–398, 96 fig. 1912.

[3] Smith, R. E., Smith, C. O., and Ramsey, H. J. Op. cit.

[4] Waite, M. B. The diseases of nut trees. *In* Rept. Proc. 4th Ann. Meeting, Northern Nut Growers' Assoc., 1913, p. 56. 1914.

planting extensively I should expect that disease to be serious. That would be my forecast of the matter. The humidity and cloudy weather in the East ought to be more favorable to the disease than the climate of California.

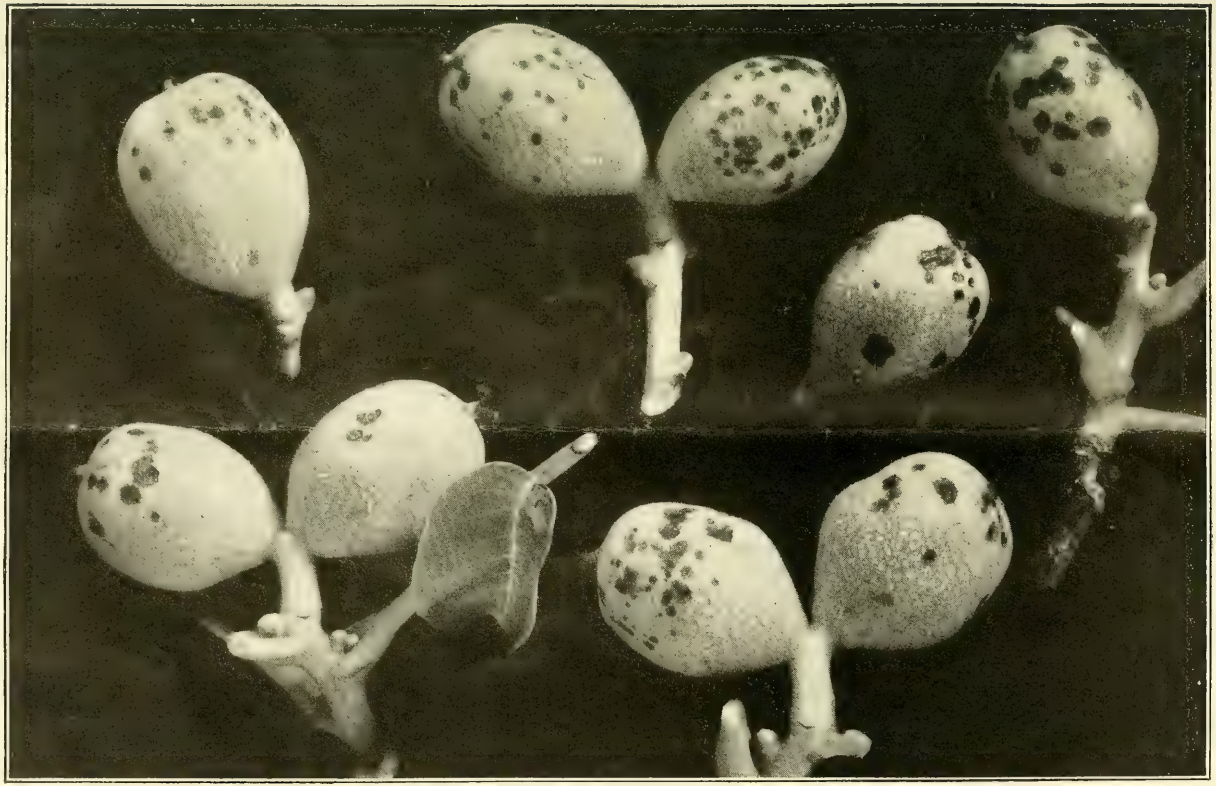
There is no reason to suppose that blight will not appear wherever Persian walnuts are grown.

THE DISEASE IN THE EASTERN STATES.

During the first week in June, 1916, a trip was made by the writer to various points in Delaware, New Jersey, and Pennsylvania where bearing walnut trees were known to be located. On practically every tree that had a crop the nuts were found to be spotted in a manner very characteristic of bacteriosis (Pl. I). The lesions at this time were small and superficial in character, rarely extending more than 2 to 3 millimeters (about one-tenth of an inch) into the husk. A number of specimens were collected and cultures obtained.

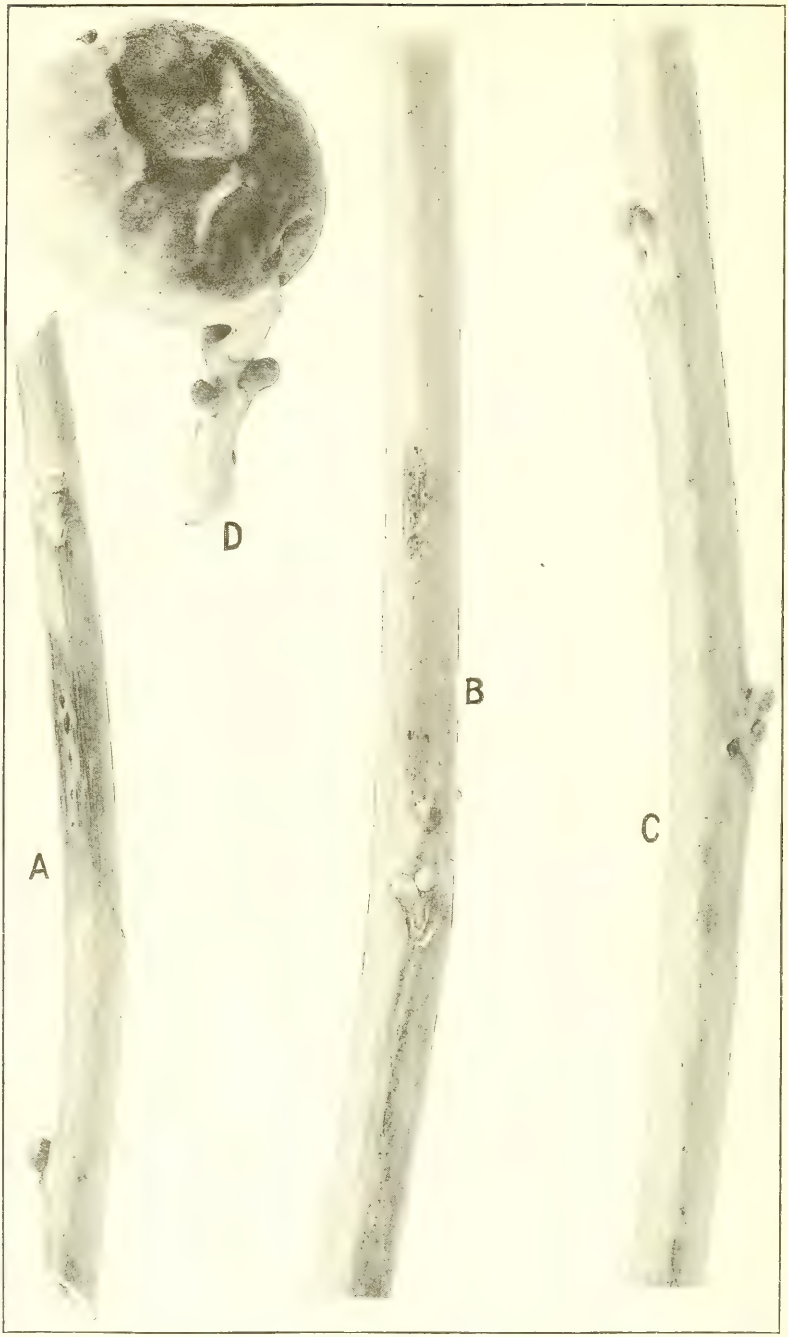
The technique used consisted in washing the nuts with soap and water, sterilizing the surface with an alcoholic solution of mercury bichlorid for five minutes, and then washing in distilled water. After this treatment the epidermis of the diseased spots was removed carefully with a sterile scalpel and bits of subepidermal tissue transferred to tubes of melted beef agar, agitated, further diluted in a second and third tube of the same media, and poured into Petri dishes. About 15 attempts were made, in practically all of which bacterial colonies of a similar type appeared on the plates in from two to four days, and the plates from the third dilutions usually contained colonies which were so few as to allow transfers to be made to tubes without difficulty. During the first week in August a series of inoculations was made on the nuts and twigs of a certain mature tree at Lancaster, Pa., which was said to be a seedling of Rush. The husks of 24 young nuts entirely free from any trace of the disease were inoculated (1) by spraying with a suspension of the germs in rain water, (2) by smearing on the culture, and (3) by puncturing with an infected needle. Several untreated nuts were tagged as controls. At the same time five young, tender, growing twigs 5 to 10 millimeters in diameter were inoculated with the germs about 6 inches from the tips by making several punctures in each with an infected needle; one twig was punctured with a sterile needle as a control. The organisms used in these experiments were all from pure cultures on beef agar and obtained as previously described.

A month later (Sept. 5, 1916) it was found that 21 of the 24 nuts inoculated had developed the disease and 3 showed no trace of it; the untreated nuts were perfectly clean. Of the five twigs inoculated, all had developed cankers from 5 to 10 mm. in length and from 2 to 5 mm. in width. Plate II shows one of the nuts 30 days after



BACTERIOSIS OF YOUNG PERSIAN WALNUTS.

The characteristic spots are caused by *Bacterium juglandis* (Pierce) Erwin F. Smith. Collected at Lancaster, Pa., June, 1916. (Natural size.)



DISEASED AND HEALTHY PERSIAN WALNUT TWIGS AND A NUT AFFECTED WITH WALNUT BLIGHT.

A and *B*, typical cankers produced on twigs in one month's time by needle punctures from pure culture; *C*, a control twig punctured with a sterile needle; *D*, a diseased nut one month after being inoculated from a pure culture by a needle puncture.

inoculation by needle puncture and two inoculated twigs having characteristic cankers. The control, which was punctured with a sterile needle, is shown at the right. The needle punctures in the control barely showed at this time, 30 days after inoculation.

Subsequently the organism was reisolated from a number of these inoculated nuts, and the cultural studies so far made from these isolations coincide with those made by Smith [1] and by Pierce.[2]

TIME OF INFECTION.

During the season of 1916 infection apparently took place about the last of May in the cases under observation. At this time the nuts were very well developed, approximately three-fourths to 1 inch in diameter, and although there was a slow increase in the area of the infection points through July and some coalescing of these spots to form larger ones, the disease did not begin to work deeply into the tissues until about the middle of August, by which time the shell had formed and hardened. By the end of the season the husks had become black, watery, and rotten, staining the shells and clinging to them when allowed to dry. The development of the nuts did not seem to be affected materially, if at all. The growers interviewed were unanimous in stating that infection was usually late and that no material shortage of crop resulted therefrom. However, the former part of this statement probably could be applied only to the time at which the infection became so evident as to attract the attention of ordinary observers.

In the California orchards the greatest loss from infection occurs at or near blooming time. Infection is serious in proportion as the weather is moist at that time. A dry, clear spring means little, if any, blight, whereas serious infection is associated with moist, foggy spring weather. The disease as observed in 1916 in Pennsylvania, Delaware, and the District of Columbia resembled closely the severe late infections described by Smith.[1]

CONTROL OF WALNUT BLIGHT.

Various attempts to control this disease by spraying and by soil applications have been made in California, and although some success has attended the spraying experiments it has not been of such degree as to extend any material encouragement to the commercial orchardist. That spraying will be of no value under eastern conditions can not be assumed from this fact, however, owing to the difference in the infection periods previously referred to. Nevertheless, spraying to control diseases of bacterial origin has never been

[1] Smith, R. E., Smith, C. O., and Ramsey, H. J. Op. cit. [2] Pierce, N. B. Op. cit.

so successful as in the control of those due to fungi; until the efficacy of spraying may have become established, too much should not be expected from this method of control.

A logical and seemingly practicable method of avoiding losses incident to bacteriosis is in the possible development of immune or highly resistant varieties. Work along this line is now under way on the Pacific coast, but it is not known that any varieties altogether resistant to blight or even practically immune to it have thus far been brought to light. However, among the many thousands of seedling trees on the Pacific coast and the hundreds in the eastern United States, it would not seem too much to presume that for general orchard planting blight-resistant and otherwise desirable varieties will yet be found. Whenever such varieties are discovered, arrangements may be made with the Department of Agriculture for testing their susceptibility to this disease by means of inoculation experiments. Meanwhile, it is to be hoped that the planting of small commercial orchards and of trees for home use will be continued, as small groups of bearing trees over a wide range of territory will furnish valuable suggestions as to future commercial plantings.

SUMMARY.

Walnut blight, or bacteriosis, is distributed very generally throughout the eastern half of the country. Investigations by Mr. M. B. Waite and the writer have demonstrated its occurrence in Louisiana, the District of Columbia, Maryland, Delaware, Pennsylvania, and New York, and there seems to be no reason to suppose that it will not occur wherever Persian walnuts are grown in the United States.

During the summer of 1916 pure cultures of the causal organism were obtained from naturally infected nuts; inoculation experiments were conducted in healthy nuts and twigs, and these inoculations were uniformly successful in producing the disease. Cultural studies were conducted in the laboratory, and the results obtained corresponded with those reported by Pierce[1] and by Smith.[2]

The writer's observations of this disease have covered one season only, and therefore definite conclusions as to its behavior under varying seasonal conditions are not possible. It may be stated, however, that late infections were the rule during the season of 1916, and if this condition holds generally true from season to season it will constitute a striking difference between the behavior of the disease in the Middle Atlantic States and on the Pacific coast.

Extensive experiments to control this disease by spraying have been conducted from time to time in California, but the results obtained have never been entirely satisfactory. Here, again, the differ-

[1] Pierce, N. B. Op. cit. [2] Smith, R. E., Smith, C. O., and Ramsey, H. J. Op. cit.

ence in infection periods may alter results, but from the best information at present available it appears that the solution of the problem of the control of this disease rests in the development of immune or highly resistant varieties. Nurserymen and growers should be on the watch for such sorts as combine a high resistance to this disease with the other qualities necessary in a good commercial nut, and whenever such varieties are found they should be propagated.

The wide planting of small lots of trees will furnish in the course of a few years valuable suggestions as to the requirements and range of the Persian walnut in the Eastern States, and should not be discouraged on account of blight. Although it is not possible at this time to say that this nut has large commercial possibilities in the section east of the Rocky Mountains, it is equally impossible to state the contrary as the fact. It is well established, however, that there are now hundreds of seedling trees in New York, Pennsylvania, New Jersey, Delaware, and Maryland bearing nuts of more or less merit despite the presence of this disease, and apparently there is no reason why every farm and country home in this district should not have a small planting of these productive as well as highly ornamental trees.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 612

Contribution from the States Relations Service
A. C. TRUE, Director.

Washington, D. C. PROFESSIONAL PAPER November 8, 1917

THE DIGESTIBILITY OF THE DASHEEN.

By C. F. Langworthy, *Chief*, and A. D. Holmes, *Specialist in Charge of Digestion Experiments, Office of Home Economics.*

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INTRODUCTION.

The dasheen, with other varieties of the taro (*Colocasia esculenta*), is a staple article of food for millions of people in tropical countries, the large, starchy tubers being ground and used like flour, cooked like potatoes, or prepared in a special way like the Hawaiian poi. Until recently these roots have been little known in this country, but of late the Department of Agriculture has given considerable attention to the selection of varieties suited to the warm localities where white potatoes do not grow well.[1] As a result, it has been found that the dasheen may be profitably grown, and attempts are being made to include it in the dietary as a starchy vegetable. Because its flavor and uses are so similar to those of the white potato, the dasheen will no doubt serve as a crop to supplement the potato supply, especially in regions where it will thrive and the potato can not be successfully grown.

[1] U. S. Dept. Agr., Bur. Plant Indus. 1110 (1914).

The tuber system of the dasheen consists of a large rootstock, or corm, and a considerable number of smaller cormels, or tubers, which branch out from the corm on all sides. The central corm may weigh from 1 to 5 or even 6 pounds. The tubers resemble sweet potatoes in shape and range of size. Inasmuch as both the corms and the tubers are edible and both are included in the harvested crop, throughout this discussion the term dasheen may be understood to refer to both.

Many tests of the culinary possibilities of the dasheen have been made by the Department of Agriculture, by home-economics workers and teachers, and by housekeepers. The general conclusion drawn from this work was very favorable to the dasheen. In general it may be said that the dasheen, which in flavor and starch is like the white potato, can be cooked in much the same way as this well-known vegetable. The flesh of the dasheen, when cooked, varies from a white or gray to a light-violet color and has a nutty flavor, which is very generally relished by those who are accustomed to it. It seems drier than white potato and many seem to feel the need for a liberal amount of butter when eating it, either baked or boiled.

A review of the literature furnished no information in regard to the digestibility of this vegetable, and so it seemed desirable to determine to what extent it is utilized by the human body. A supply of dasheens of uniform quality, grown under known soil and climatic conditions, was secured for this purpose through the cooperation of the Bureau of Plant Industry from one of its experimental fields in Florida.

NATURE OF THE DIET DURING THE TEST PERIODS.

Since carbohydrates would be the chief nutrient introduced into the diet by the dasheen, in this study attention has centered on the digestibility of this constituent, though data are also reported for protein, fat, and ash. Accordingly, in selecting the basal ration, foods were chosen which contained a minimum amount of carbohydrates, a simple basal diet consisting of milk, fruit, butter, and tea or coffee, if any liquid other than water was desired, being served in conjunction with the dasheen. The object was to have a diet simple in character and meeting the experimental requirements, yet sufficiently palatable to be eaten for three days (the length of the experimental periods) without being monotonous, and also varied enough to be comparable with an ordinary mixed diet. That experimental rations thus planned give satisfactory results has been the experience of this office. To insure the consumption of fairly large amounts of dasheen the subjects were urged to eat freely of it, and at the same time they

were not restricted with respect to the amounts of the accessary foods eaten. As a result the amounts of food eaten during the different test periods varied quite materially.

SUBJECTS.

The subjects who assisted in this investigation were strong, healthy men, with normal appetites and digestive functions, whose ages varied from 20 to 40 years. With one exception they were all students in local institutions. Since all had more or less muscular exercise, it seems fair to regard them as engaged in light muscular work rather than as of sedentary occupation. Their normal dietary was simple and, except that it contained meat, was not materially different from that of the experimental periods and, accordingly, the change from one type of diet to the other was not accompanied by any noticeable physiological disturbances. The subjects were instructed to submit a report of their physical condition during the experimental period and in every instance they stated that they were in normal condition. Inasmuch as this study of the dasheen was primarily concerned with the coefficients of digestibility, no attempt was made to maintain a uniform body weight and no record was kept of the weight of the subjects. The ration for each subject was prepared and weighed in advance. They were instructed to reserve any uneaten portions of the diet for analysis, and how to collect feces resulting from the experimental diet.

RELATION BETWEEN MATURITY AND DIGESTIBILITY.

In addition to considering the general question of digestibility it seemed desirable also to determine whether or not maturity of the dasheen influenced their digestibility. Obviously, for this purpose dasheens were needed which were as nearly alike as possible except in respect to maturity at the time of harvesting. The Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, accordingly provided representative samples of immature and mature dasheens grown under controlled conditions at the plant introduction field station, Brooksville, Fla. Rows which were adjudged to be typical of the field were chosen, and about six weeks before the usual harvesting time the alternate plants were harvested and their entire root systems forwarded to this laboratory as were also the tubers of the remaining plants when later they were considered to be mature. The tubers in both cases were eaten less than a week after being removed from the ground.

Experiments Nos. 513, 514, and 519 to 522 report results obtained with the immature dasheen, while the remaining four experiments (Nos. 543 to 546) are concerned with the digestibility of the mature tubers. All experimental conditions were maintained as nearly identical as possible in both sets of experiments, and, accordingly, the results reported should be directly comparable.

DETAILS OF THE EXPERIMENTS.

In general, the methods employed in this investigation were the same as those for similar experiments reported in recent publications[1] of this office. Considerable care was exercised in preparing and serving the experimental diet so that all the foods eaten by the different subjects at the different meals should be of uniform composition. The accessory foods (milk, fruit, butter) were so chosen and prepared as to be quite uniform in composition; they were eaten as purchased and were not cooked in any way.

The dasheen, in sufficient quantities to supply all the subjects for the entire period of each experiment, was prepared at the beginning of the test period. In every case it was parboiled until the outer portion could be pierced with a fork, and then baked until the center of the tubers was thoroughly softened, a method of preparation which experience has shown to be satisfactory as regards quality and economy of time and which is in accord with a common practice. The entire tuberous structure of the plants was used in every case. As was to be expected, it was found that the time required for baking the large corms was considerably greater than that necessary for the smaller cormels or tubers. When thoroughly baked, the thick skin was removed at once and the dasheens were passed through a potato ricer while still hot, since they do not "rice" well when cool. They were then thoroughly mixed to insure uniformity and for each test a representative sample was reserved for analysis. The 10 experiments here reported occurred at three intervals—two experiments (Nos. 513 and 514), beginning September 28; four experiments (Nos. 519 to 522), beginning October 10; and four experiments (Nos. 543 to 546), beginning November 22. The subjects were permitted to warm the dasheen before eating it if they so desired, but when they did so they were required to leave none uneaten. Butter was eaten with the dasheen, each man using, on an average, approximately 110 grams of butter daily, equivalent to 90 grams or more of butter fat.

The separation of the feces resulting from the diet was accomplished by means of lampblack taken in gelatin capsules with the first

[1] See list on p. 12.

meal of the experimental period and with the first meal succeeding the test period; the resulting dark coloration of a portion of the feces makes it possible, generally, to separate very accurately the feces from the experimental diet from the remainder voided at the same time. The feces for each experiment were deposited in tared glass containers and were dried in an electric oven regulated to maintain a temperature of 95° C. When dry, the total amount of feces for each subject was finely ground and thoroughly mixed for analysis. Samples of both food and feces, the latter reported on "water-free" basis, were analyzed to determine the percentages of protein, fat, and carbohydrates, according to the methods outlined by the Association of Official Agricultural Chemists,[1] and from a comparison of the results it was determined how much was actually digested.

The data essential for the interpretation of the results of the digestion experiments are given in the tables below, and include the total amount of food eaten, the amounts of protein, fat, and carbohydrates supplied, the weights of the feces and their constituents, and the coefficients of digestibility of the protein, fat, and carbohydrates of the diet.

EXPERIMENTS WITH IMMATURE DASHEENS.

Six experiments were made with immature dasheens and, while these were not all carried on at the same time, the subjects and all experimental conditions were the same throughout. The results are given in the following table:

Data of digestion experiments with immature dasheens in a simple mixed diet.

Food.	Total.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 513, subject A. J. H.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dasheen	1,430.0	983.1	24.2	2.3	406.4	14.0
Milk	2,530.0	2,201.1	75.9	101.2	126.5	25.3
Fruit	131.0	113.8	1.0	0.3	15.2	0.7
Butter	482.0	53.0	4.8	409.7	.....	14.5
Total food consumed	4,573.0	3,351.0	105.9	513.5	548.1	54.5
Feces	98.0	.....	33.4	30.6	17.7	16.3
Amount utilized	.....	.....	72.5	482.9	530.4	38.2
Per cent utilized	.....	.....	68.5	94.0	96.8	70.1
Experiment No. 514, subject P. K.:						
Dasheen	1,599.0	1,099.3	27.0	2.6	454.4	15.7
Milk	2,363.0	2,055.8	70.9	94.5	118.2	23.6
Fruit	741.0	643.9	5.9	1.5	86.0	3.7
Butter	340.0	37.4	3.4	289.0	.....	10.2
Total food consumed	5,043.0	3,836.4	107.2	387.6	658.6	53.2
Feces	34.0	.....	10.0	8.2	10.6	5.2
Amount utilized	.....	.....	97.2	379.4	648.0	48.0
Per cent utilized	.....	.....	90.7	97.9	98.4	90.2

[1] U. S. Dept. Agr., Bur. Chem. Bul. 107 (1912), rev. ed.

Data of digestion experiments with immature dasheens in a simple mixed diet—Continued.

Food.	Total.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 519, subject H. R. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dasheen	1,900.0	1,291.0	40.5	2.7	546.2	19.6
Milk	2,625.0	2,283.8	78.7	105.0	131.3	26.2
Fruit	373.0	324.1	3.0	0.7	43.3	1.9
Butter	153.0	16.8	1.5	130.1	.....	4.6
Total food consumed	5,051.0	3,915.7	123.7	238.5	720.8	52.3
Feces	71.0	.....	30.9	10.6	18.0	11.5
Amount utilized	.....	.....	92.8	227.9	702.8	40.8
Per cent utilized	.....	.....	75.0	95.6	97.5	78.0
Experiment No. 520, subject A. J. H.:						
Dasheen	1,335.0	907.1	28.4	1.9	383.8	13.8
Milk	2,702.0	2,350.7	81.1	108.1	135.1	27.0
Fruit	68.0	59.1	0.6	0.1	7.9	0.3
Butter	356.0	39.2	3.5	302.6	.....	10.7
Total food consumed	4,461.0	3,356.1	113.6	412.7	526.8	51.8
Feces	65.0	.....	22.8	10.0	20.5	11.7
Amount utilized	.....	.....	90.8	402.7	506.3	40.1
Per cent utilized	.....	.....	79.9	97.6	96.1	77.4
Experiment No. 521, subject P. K.:						
Dasheen	1,960.0	1,331.8	41.8	2.7	563.5	20.2
Milk	2,610.0	2,270.7	78.3	104.4	130.5	26.1
Fruit	839.0	729.1	6.7	1.7	97.3	4.2
Butter	458.0	50.4	4.6	389.3	.....	13.7
Total food consumed	5,867.0	4,382.0	131.4	498.1	791.3	64.2
Feces	61.0	.....	19.4	18.0	12.2	11.4
Amount utilized	.....	.....	112.0	480.1	779.1	52.8
Per cent utilized	.....	.....	85.2	96.4	98.5	82.2
Experiment No. 522, subject C. J. W.:						
Dasheen	2,194.0	1,490.8	46.7	3.1	630.8	22.6
Milk	2,549.0	2,217.6	76.5	102.0	127.4	25.5
Fruit	966.0	839.5	7.7	1.9	112.1	4.8
Butter	164.0	18.1	1.6	139.4	.....	4.9
Total food consumed	5,873.0	4,566.0	132.5	246.4	870.3	57.8
Feces	68.0	.....	26.5	10.2	19.0	12.3
Amount utilized	.....	.....	106.0	236.2	851.3	45.5
Per ecnt utilized	.....	.....	80.0	95.9	97.8	78.7
Average food consumed per subject per day	1,714.9	1,300.4	39.7	127.6	228.7	18.5

Summary of digestion experiments with immature dasheens in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
513	A. J. H.	68.5	94.0	96.8	70.1
514	P. K.	90.7	97.9	98.4	90.2
519	H. R. G.	75.0	95.6	97.5	78.0
520	A. J. H.	79.9	97.6	96.1	77.4
521	P. K.	85.2	96.4	98.5	82.2
522	C. J. W.	80.0	95.9	97.8	78.7
Average	.....	79.9	96.2	97.5	79.4

The variations which occurred in the results obtained in the two sets of experiments were immaterial. Furthermore, the results of the individual experiments agree quite closely with one another with respect to the figures commonly reported for the carbohydrates.

During these six tests the subjects ate on an average 40 grams of protein, 128 grams of fat, and 229 grams of carbohydrates, which were 79.9 per cent, 96.2 per cent, and 97.5 per cent digested, respectively. These values indicate a very complete utilization of this diet by the human body.

EXPERIMENTS WITH MATURE DASHEENS.

The results of four experiments with mature dasheens are given in the following table:

Data of digestion experiments with mature dasheens in a simple mixed diet.

Food.	Total.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 543, subject H. R. G.:	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*
Dasheen	1,128.0	719.6	27.5	2.8	367.2	10.9
Milk	2,604.0	2,265.5	78.1	104.2	130.2	26.0
Fruit	462.0	401.5	3.7	.9	53.6	2.3
Butter	143.0	15.7	1.4	121.6	.....	4.3
Total food consumed	4,337.0	3,402.3	110.7	229.5	551.0	43.5
Feces	59.0	.....	22.4	10.4	15.5	10.7
Amount utilized	.....	.....	88.3	219.1	535.5	32.8
Per cent utilized	.....	.....	79.8	95.5	97.2	75.4
Experiment No. 544, subject A. J. H.:						
Dasheen	1,247.0	795.5	30.4	3.1	405.9	12.1
Milk	2,897.0	2,520.4	86.9	115.9	144.8	29.0
Fruit	95.0	82.5	.8	.2	11.0	.5
Butter	436.0	48.0	4.3	370.6	.....	13.1
Total food consumed	4,675.0	3,446.4	122.4	489.8	561.7	54.7
Feces	52.0	.....	15.4	24.4	3.3	8.9
Amount utilized	.....	.....	107.0	465.4	558.4	45.8
Per cent utilized	.....	.....	87.4	95.0	99.4	83.7
Experiment No. 545, subject P. K.:						
Dasheen	1,848.0	1,178.9	45.1	4.6	601.5	17.9
Milk	2,942.0	2,559.5	88.3	117.7	147.1	29.4
Fruit	849.0	737.8	6.8	1.7	98.5	4.2
Butter	490.0	53.9	4.9	416.5	.....	14.7
Total food consumed	6,129.0	4,530.1	145.1	540.5	847.1	66.2
Feces	57.0	.....	17.2	16.5	12.5	10.8
Amount utilized	.....	.....	127.9	524.0	834.6	55.4
Per cent utilized	.....	.....	88.1	96.9	98.5	83.7
Experiment No. 546, subject C. J. W.:						
Dasheen	1,763.0	1,124.6	43.0	4.4	573.9	17.1
Milk	2,945.0	2,562.1	88.4	117.8	147.2	29.5
Fruit	1,048.0	910.7	8.4	2.1	121.6	5.2
Butter	236.0	26.0	2.3	200.6	.....	7.1
Total food consumed	5,992.0	4,623.4	142.1	324.9	842.7	58.9
Feces	110.0	.....	38.2	13.9	37.1	20.8
Amount utilized	.....	.....	103.9	311.0	805.6	38.1
Per cent utilized	.....	.....	73.1	95.7	95.6	64.7
Average food consumed per subject per day	1,761.1	1,333.5	43.4	132.1	233.5	18.6

Summary of digestion experiments with mature dasheen in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
543	H. R. G.	79.8	95.5	97.2	75.4
544	A. J. H.	87.4	95.0	99.4	83.7
545	P. K.	88.1	96.9	98.5	83.7
546	C. J. W.	73.1	95.7	95.6	64.7
Average		82.1	95.8	97.7	76.9

In the experiments with mature dasheens the subjects ate, on an average, 41 grams of protein, 129 grams of fat, and 231 grams of carbohydrates, of which 82.1 per cent, 95.8 per cent, and 97.7 per cent, respectively, were retained in the body. These values, except for protein, agree quite closely with those reported for an ordinary mixed diet,[1] which are, for protein, 92 per cent; for fat, 95 per cent; and for carbohydrates, 97 per cent. Perhaps the low coefficient of digestibility of the protein obtained may be due to the fact that only 41 grams were taken per man per day; it has long been recognized that the feces contain nitrogen aside from that derived from the diet, and this becomes proportionately larger as the nitrogen intake decreases. The coefficient of digestibility obtained for the carbohydrates of the mature dasheen, 97.7 per cent, would indicate that they are very well assimilated.

SUMMARY OF ALL EXPERIMENTS.

The following table summarizes the results of all the experiments reported:

Summary of all digestion experiments with dasheens in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
513	A. J. H.	68.5	94.0	96.8	70.1
514	P. K.	90.7	97.9	98.4	90.2
519	H. R. G.	75.0	95.6	97.5	78.0
520	A. J. H.	79.9	97.6	96.1	77.4
521	P. K.	85.2	96.4	98.5	82.2
522	C. J. W.	80.0	95.9	97.8	78.7
543	H. R. G.	79.8	95.5	97.2	75.4
544	A. J. H.	87.4	95.0	99.4	83.7
545	P. K.	88.1	96.9	98.5	83.7
546	C. J. W.	73.1	95.7	95.6	64.7
Average		80.8	96.1	97.6	78.4

The average amount of food consumed per subject per day in all experiments was 1,733.4 grams, furnishing 1,313.6 grams of water, 41.2 grams of protein, 129.4 grams of fat, 230.6 grams of carbohydrates, and 18.6 grams of ash.

[1] Connecticut Storrs Sta. Rpt. 1901, p. 245.

DISCUSSION OF RESULTS.

The amount of dasheen eaten during the test periods varies from an average of 376 grams per man per day in experiment No. 543 to an average of 731 grams per man per day in experiment No. 522, the general average for the 10 experiments being 547 grams per man per day.

Considering the 10 experiments with both the immature and mature dasheen together (see p. 8), it will be seen that, on an average, 41 grams of protein, 129 grams of fat, and 231 grams of carbohydrates were eaten per man per day, of which 80.8 per cent of the protein, 96.1 per cent of the fat, and 97.6 per cent of the carbohydrates supplied by the total diet were digested.

The coefficient of digestibility of the fat (99 per cent of which was butter fat) furnished by the diet is not without interest. The reported value, 96.1 per cent, approximates the value (97 per cent) obtained in a study of the digestibility[1] of butter, in which the diet was of an entirely different nature, namely, blancmange (containing large amounts of butter), wheat biscuit, fruit, and tea or coffee with sugar. In a later investigation,[2] in which butter supplied the greater proportion of the fat of a diet of still different nature (hard palates of cattle served in the form of a meat loaf, containing butter, potato, crackers, and sugar), butter fat was found to be 95 per cent digested. The amounts of butter fat eaten per subject per day in the experiments with dasheen, with butter, and with hard palates were 128 grams, 97 grams, and 106 grams, respectively. This agreement between the values determined for the digestibility of butter, when eaten with different types of diets and under identical experimental conditions, furnishes additional basis for the belief that a fat included in a mixed diet is digested equally well regardless of the nature of the other constituents of the diet.

As regards the amounts of nutrients supplied by dasheens of different maturity, it will be seen that in the six experiments with the immature dasheen an average of 40 grams of protein, 128 grams of fat, and 229 grams of carbohydrates was eaten per man per day, while in the four experiments with the mature dasheen the average amounts were for all practical purposes identical, being 43 grams of protein, 132 grams of fat, and 234 grams of carbohydrates daily.

The average coefficient of digestibility of the carbohydrates of immature and of mature dasheens was 97.5 per cent and 97.7 per cent, respectively. Apparently in so far as the thoroughness of digestion

[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.
[2] U. S. Dept. Agr., Jour. Agr. Research, 6 (1916), No. 17, p. 647.

of the dasheen carbohydrates is concerned, it would seem immaterial whether the well-grown dasheen is mature or immature when harvested.

The difference in the amounts of carbohydrates supplied by the total diet eaten per subject per day in the various tests was quite large, varying from a minimum of 176 grams in experiment No. 520 to a maximum of 290 grams in experiment No. 522, with an average daily consumption of 231 grams. On the whole, the differences in the values obtained for the digestibility of the carbohydrates with the different subjects in the different tests is small, and such variations as were found in the digestibility of the carbohydrates did not correspond to observed variations in the amounts of carbohydrates eaten.

Comparing the average value found for the digestibility of the carbohydrates of the dasheen, 97.6 per cent, with that reported for the carbohydrates of the potato, no significant difference is found. Bryant and Milner[1] on the basis of three experiments report the digestibility of potato carbohydrates to be 99.0 per cent; in an experiment reported by Rubner[2] the coefficient of digestibility was 92.4 per cent; while Constantinidi[3] found that an average of 99.6 per cent of the potato carbohydrates was utilized by the human body.

CONCLUSIONS.

In 10 digestion experiments with men, mature and immature dasheens were eaten in conjunction with common food materials in a simple mixed diet. The average coefficients of digestibility for the total diet were: Protein, 80.8 per cent; fat, 96.1 per cent; and carbohydrates, 97.6 per cent.

The value obtained for the digestibility of the carbohydrates, 97.6 per cent, which for all practical purposes represents the digestibility of the dasheen carbohydrates, compares very favorably with that of potatoes, the common vegetable most resembling the dasheen.

The subjects of their own volition ate on an average approximately 1¼ pounds of dasheen daily without any observed physiological disturbances, which would indicate that considerable amounts of dasheens may be safely used in the dietary and that they are palatable.

The results here reported were obtained from dasheens cooked by one method only: in the absence of data to the contrary it may be

[1] Amer. Jour. Physiol., 10 (1903), No. 2, p. 96.
[2] Ztschr. Biol., 15 (1879), No. 1, p. 148.
[3] Ztschr. Biol., 23 (1887), p. 449.

very well assumed that the dasheen is equally well digested when prepared by other methods similar to those employed with potatoes.

The data obtained in this investigation give evidence to justify the belief that the dasheen is a valuable addition to the dietary, that it can replace the potato in those regions where the potato can not be successfully grown or easily obtained, and that it is also valuable for more general use to give greater variety to the diet in other localities.

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Studies on the Influence of Cooking upon the Nutritive Value of Meats at the University of Illinois, 1903–1904. By H. S. Grindley, D. Sc., and A. D. Emmett, A. M. Pp. 230, tables 136. 1905. (Office of Experiment Stations Bulletin 162) Price, 20 cents.

Studies of the Effect of Different Methods of Cooking upon the Thoroughness and Ease of Digestion of Meats at the University of Illinois. H. S. Grindley, D. Sc., Timothy Mojonnier, M. S., and Horace C. Porter, Ph. D. Pp. 100, tables 38. 1907. (Office of Experiment Stations Bulletin 193.) Price, 15 cents.

Digestibility of Some Animal Fats. By C. F. Langworthy and A. D. Holmes. Pp. 23. 1915. (Department Bulletin 310.) Price, 5 cents.

Digestibility of Very Young Veal. By C. F. Langworthy and A. D. Holmes. Pp. 577–588. 1916. (Journal of Agricultural Research, 6 (1916), No. 16.) Price, 5 cents.

Digestibility of Hard Palates of Cattle. By C. F. Langworthy and A. D. Holmes. Pp. 641–648. 1916. (Journal of Agricultural Research, 6 (1916), No. 17.) Price, 5 cents.

Studies on the Digestibility of the Grain Sorghums. By C. F. Langworthy and A. D. Holmes. Pp. 30. 1916. (Department Bulletin 470. Price, 5 cents.

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Experiments in the Determination of the Digestibility of Millets. By C. F. Langworthy and A. D. Holmes. Pp. 11. 1917. (Department Bulletin 525.) Price, 5 cents.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 613

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A. C. TRUE, Director

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DIGESTIBILITY OF CERTAIN MISCELLANEOUS ANIMAL FATS.[1]

By ARTHUR D. HOLMES, *Specialist in Charge of Digestion Experiments, Office of Home Economics.*

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INTRODUCTION.

Earlier papers[2] of this series have reported the coefficients of digestibility of lard, beef and mutton fats, and butter; cream, chicken, goose, egg-yolk, brisket and fish fats; olive, cottonseed, peanut, coconut and sesame oils and cocoa butter; almond, black-walnut, Brazil nut, butternut, English walnut, hickory nut, and pecan oils; corn, soy-bean, sunflower-seed, Japanese mustard-seed, rapeseed and charlock-seed oils. The present paper deals with the digestibility of goat's butter, kid fat, hard-palate fat, horse fat, oleo oil, oleo stearin, ox-marrow, ox-tail, and turtle fats. Though oleo oil and oleo stearin are of much importance commercially, the fats discussed in this bulletin, as a whole, are not commonly known in American homes. However, they are, for one reason or another, of interest in considering culinary and table fats as well as in the consideration of general problems related to the use of fats as food. A few of these fats were purchased in the open market and the remainder were secured through the cooperation of Government and commercial activities. The hard-palate, horse, kid, and turtle fats were rendered in the laboratory by cutting the unrendered fat very fine, heating in a double boiler until the fat was completely melted, and then straining through rather thick cloth. The oleo oil, oleo

[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.
[2] See list of bulletins on page 26.

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stearin, ox-marrow, and ox-tail fats were obtained already rendered from commercial concerns. In order to insure uniform composition a sufficient quantity of each of the fats for the purpose of the study was thoroughly mixed before it was incorporated in the blancmange, which served as a medium for supplying the fat to the diet.

METHODS OF PROCEDURE.

The regimen followed was the same as that in previous experiments, foods containing a minimum amount of fat being chosen as a basal diet, i. e., wheat biscuits, oranges, and sugar. The fat to be studied was incorporated in a cornstarch pudding, a caramel solution being added to conceal any pronounced flavor. A sufficient amount of this pudding was prepared for the entire experiment. It was desired that such quantities as were necessary to provide about 100 grams of fat should be eaten by each subject daily, this amount being approximately one-third the total energy of the diet which is the average proportion furnished by fat. Coffee and tea, without cream, were permitted according to individual preference. The experimental diet was eaten for three days or nine meals in each case. This period has been found satisfactory in the previous tests as it is sufficient to give satisfactory results and not so long as to introduce any undesirable physiological effect due to monotony. A 4-days period of normal diet was always followed before beginning a new test.

For separation of the feces from this diet, charcoal was administered in gelatin capsules with the first meal on the fat-containing diet, and with the first meal on resuming the customary diet. The feces were collected in weighed-glass containers, weighed, and then dried in an electric oven at 95° C., pulverized and analyzed. No urine analyses were made and no effort to maintain a nitrogen equilibrium, the digestibility of the fats being the special object of investigation. The coefficients of digestibility of the protein, fat, and carbohydrate supplied by the diet as a whole were determined directly. From these data the digestibility of the fat under consideration was estimated by the method commonly followed and outlined in detail in a previous bulletin.[1] In computing the figure for digestibility of the fat alone, in each experiment correction was made for metabolic products and the small amount of undigested basal ration fat which occurs in the ether extract of the feces.

In general it has been the practice during the study of the digestibility of the edible fats to conduct not less than five tests of three days' duration each. Since the available supply of fat in the case of a number of fats here studied was small, as few as three experiments were made in some instances.

[1] U. S. Dept. Agr. Bul. 310 (1915), pp. 22.

SUBJECTS.

The subjects were all men who had previously served in the same capacity. They were between 20 and 40 years of age, in good health, and took a moderate amount of exercise. They observed regular hours for meals and followed their normal daily occupations. Since the subjects were students, they would be classed properly as persons engaged in light muscular activities. All were in good physical condition, possessing healthy appetites and normal digestive functions.

GOAT'S BUTTER.

Goat's milk, butter, and cheese have long been common foods in many localities in Europe, yet, aside from chemical analyses, seem to have been little studied. It has long been believed that goat's milk is in some way superior to cow's milk for infant feeding. This belief is probably based on the result of empirical observations for the data found in the literature does not uniformly substantiate such a belief. To obtain more complete data on the relative nutritive values of goat's and cow's milk, Sherman and Lohnes[1] made a comparative study of the two with infants and found that the curds of goat's milk were smaller and more flocculent than those of cow's milk, that goat's milk has finer fat globules and exhibits more thorough emulsification of the fat; that cow's milk has greater stimulating effect on the stomach; that in 16 cases, 12 babies gained more rapidly on cow's milk and 4 more rapidly on goat's milk; that 5 vomited on goat's milk and none on cow's milk; and that children taking goat's milk cried more at night. Bosworth and Van Slyke,[2] who have studied the nature of the casein[3] and soluble and insoluble compounds of goat's milk[4] and compared the composition of cow's, goat's, and human milk,[5] report that goat's milk[6] is less acid, contains a larger amount of chlorids, and that the phosphates are combined with more bases than in cow's milk. Jordan and Smith[6] have made extensive analyses of goat's milk. They concluded that there was no essential difference between the casein, but that there were marked differences in the nature of the ash obtained from cow's and goat's milk. Hall[7] states that goat's milk is palatable, nutritious, easily digested, helpful in certain cases of poor nutrition, and practically free from liability to transmit diseases like tuberculosis.

Very recently Hill[8] has reported a series of chemical analyses of milk produced by a four-months-old virgin doe kid, and states: "The

[1] Jour. Amer. Med. Assoc., 62 (1914), No. 23, pp. 1806, 1807.
[2] N. Y. State Agr. Expt. Sta. Tech. Bul., 46 (1915), p. 3.
[3] Jour. Biol. Chem., 24 (1916), No. 3, pp. 173–175.
[4] Jour. Biol. Chem., 24 (1916), No. 3, pp. 177–185.
[5] Jour. Biol. Chem., 24 (1916), No. 3, pp. 187–189.
[6] N. Y. State Agr. Expt. Sta. Bul., 429 (1917), p. 4.
[7] N. Y. State Agr. Expt. Sta. Bul., 429 (1917), pop. ed., p. 7.
[8] Jour. Biol. Chem., 33 (1918), No. 3, p. 392.

milk was substituted in the diet of an 11-months-old baby for normal goat's milk without any detectable difference either in the appetite or physical condition of the baby."

The literature consulted gave no information as to the presence or absence in goat's milk and butter of the fat-soluble vitamin contained in cow's butter. In view of the use of goat's milk for infant feeding, information on this point would be of especial importance, since goat's milk is in many parts of the world the common household milk supply.

A supply of goat's butter sufficient for the purpose of these experiments was obtained from the Dairy Division of the Bureau of Animal Industry. The butter was of a very pale-yellow color, without pronounced odor or flavor, and by those not informed of its nature it was taken for light-colored dairy butter. Since only a limited supply was available, no tests were made regarding its use in cookery, and the entire sample was incorporated in the usual cornstarch blancmange.

Four experiments were conducted to determine the digestibility of goat's butter and the data which resulted are recorded in the following tables:

Data of digestion experiments with goat's-milk butter in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 645, subject A. F.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing goat's milk butter.	2,086.0	1,176.4	54.8	144.1	699.0	11.7
Wheat biscuit	245.0	22.0	26.0	3.7	189.4	3.9
Fruit	829.0	720.4	6.6	1.7	96.2	4.1
Sugar	152.0				152.0	
Total food consumed	3,312.0	1,918.8	87.4	149.5	1,136.6	19.7
Feces	76.0		24.8	11.3	31.9	8.0
Amount utilized			62.6	138.2	1,104.7	11.7
Per cent utilized			71.6	92.4	97.2	59.4
Experiment No. 646, subject P. K.:						
Blancmange containing goat's milk butter.	1,809.0	1,020.3	47.4	125.0	606.2	10.1
Wheat biscuit	248.0	22.3	26.3	3.7	191.7	4.0
Fruit	502.0	436.3	4.0	1.0	58.2	2.5
Sugar	191.0				191.0	
Total food consumed	2,750.0	1,478.9	77.7	129.7	1,047.1	16.6
Feces	51.0		18.0	8.1	20.2	4.7
Amount utilized			59.7	121.6	1,026.9	11.9
Per cent utilized			76.8	93.8	98.1	71.7
Experiment No. 647, subject J. C. M.:						
Blancmange containing goat's milk butter.	1,775.0	1,001.1	46.6	122.6	594.8	9.9
Wheat biscuit	316.0	28.4	33.5	4.7	244.3	5.1
Fruit	384.0	333.7	3.1	.8	44.5	1.9
Sugar	175.0				175.0	
Total food consumed	2,650.0	1,363.2	83.2	128.1	1,058.6	16.9
Feces	70.0		23.0	8.6	32.4	6.0
Amount utilized			60.2	119.5	1,026.2	10.9
Per cent utilized			72.4	93.3	96.9	64.5

Data of digestion experiments with goat's-milk butter in a simple mixed diet—Continued.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 648, subject A. A. R.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing goat's milk butter	1,770.0	998.3	46.4	122.3	593.1	9.9
Wheat biscuit	192.0	17.3	20.3	2.9	148.4	3.1
Fruit	1,059.0	920.3	8.5	2.1	122.8	5.3
Sugar	210.0	.....	.....	.....	210.0	.....
Total food consumed	3,231.0	1,935.9	75.2	127.3	1,074.3	18.3
Feces	71.0	.....	25.0	6.6	33.0	6.4
Amount utilized	.....	.....	50.2	120.7	1,041.3	11.9
Per cent utilized	.....	.....	66.8	94.8	96.9	65.0
Average food consumed per subject per day	995.3	558.1	27.0	44.6	359.7	6.0

Summary of digestion experiments with goat's-milk butter in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of goat's milk butter alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
645	A. F.	71.6	92.4	97.2	59.4	97.4
646	P. K.	76.9	93.8	98.1	71.7	97.5
647	J. C. M.	72.4	93.3	96.9	64.5	98.6
648	A. A. R.	66.8	94.8	96.9	65.0	100.0
Average		71.9	93.6	97.3	65.2	98.4

Considering the diet as a whole, the subjects ate on an average 27 grams of protein, 45 grams of fat, and 360 grams of carbohydrate daily, which supplied approximately 2,079 calories of energy. Since the available amount of goat's butter was small, only about 45 grams of fat, of which about 43 grams was goat's butter, was eaten daily.

The digestibility was found to be 71.9 per cent for protein, 93.6 per cent for fat, and 97.3 per cent for the carbohydrate supplied by the diet as a whole. When correction is made for the metabolic products and undigested basal-ration fat which occurs in the ether extract of the feces, the figure 93.6 per cent for the digestibility of the total fat of the diet becomes 98.4 per cent for the digestibility of goat's butter alone.

For the sake of comparison it is of interest in this connection to refer to the figure for the digestibility of cow's butter[1] determined under conditions identical with those maintained for the experiments here reported. This was found to be 97 per cent, a difference, which for all practical dietetic purposes is negligible as compared with 99

[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

per cent, the digestibility of goat's butter. Since all the subjects reported that they were in normal physical condition during the entire period of these experiments, it appears that goat's butter is a wholesome valuable food fat.

KID FAT.

The consumption of kid fat is quite limited in this country, being confined largely to those of foreign birth and food habits, who include goat or kid meat in their dietary. Just as the consumption of lamb greatly exceeds that of mutton, the amount of kid meat eaten exceeds that of goat meat. Kid fat has little if any sale in this country as an edible fat; however, it seemed of interest to compare its digestibility with that of mutton fat.

Through the courtesy of the Bureau of Animal Industry, one-half of the carcass of a 6-months-old kid was secured for experimental purposes. The kidney fat and all of the superficial fat was carefully removed, finely cut, and rendered in a double boiler. The meat was cooked and its digestibility determined by means of the usual digestion experiments, the results of which are reserved for future discussion. The fat which cooked out of the meat was carefully saved and, since it had not been scorched and was free from any suspended matter, was added to the rendered kidney fat in order that a sufficient quantity of fat should be available for the experiments reported below.

Data of digestion experiments with kid fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 712, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing kid fat	1,506.0	813.1	27.7	177.0	476.5	11.7
Wheat biscuit	319.0	28.7	33.8	4.8	246.6	5.1
Fruit	492.0	427.5	3.9	1.0	57.1	2.5
Sugar	197.0	.....	.....	.....	197.0	.....
Total food consumed	2,514.0	1,269.3	65.4	182.8	977.2	19.3
Feces	72.0	.....	7.0	16.5	41.9	6.6
Amount utilized	.....	.....	58.4	166.3	935.3	12.7
Per cent utilized	.....	.....	89.3	91.0	95.7	65.8
Experiment No. 713, subject J. C. M.:						
Blancmange containing kid fat	1,641.0	886.0	30.2	192.8	519.2	12.8
Wheat biscuit	388.0	34.9	41.2	5.8	299.9	6.2
Fruit	1,013.0	880.3	8.1	2.0	117.5	5.1
Sugar	149.0	.....	.....	.....	149.0	.....
Total food consumed	3,191.0	1,801.2	79.5	200.6	1,085.6	24.1
Feces	69.0	.....	2.3	9.7	50.9	6.1
Amount utilized	.....	.....	77.2	190.9	1,034.7	18.0
Per cent utilized	.....	.....	97.1	95.2	95.3	74.7

Data of digestion experiments with kid fat in a simple mixed diet—Continued.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 714, subject A. A. R.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing kid fat	1,428.9	771.0	26.3	167.8	451.8	11.1
Wheat biscuit	237.0	21.3	25.1	3.6	183.2	3.8
Fruit	1,204.0	1,046.3	9.6	2.4	139.7	6.0
Sugar	168.0	.....	.....	.....	168.0	.....
Total food consumed	3,037.0	1,838.6	61.0	173.8	942.7	20.9
Feces	104.0	.....	13.1	21.4	59.4	10.1
Amount utilized	.....	.....	47.9	152.4	883.3	10.8
Per cent utilized	.....	.....	78.5	87.7	93.7	51.7
Average food consumed per subject per day	971.3	945.5	22.9	61.9	333.9	7.1

Summary of digestion experiments with kid fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of kid fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Percent.*	*Per cent.*	*Per cent.*	*Per cent.*
712	P. K.	89.3	91.0	95.7	65.8	94.1
713	J. C. M.	97.1	95.2	95.3	74.7	98.4
714	A. A. R.	78.5	87.7	93.7	51.7	93.4
Average		88.3	91.3	94.9	64.1	95.3

The coefficients of digestibility of the diet as a whole were found to be 88.3 per cent for protein, 91.3 per cent for fat, 94.9 per cent for carbohydrate, and the estimated digestibility of kid fat alone is 95.3 per cent. This figure obtained for the digestibility of kid fat is perhaps not directly comparable with the coefficient of digestibility, 88 per cent, previously reported[1] for mutton fat, since the mutton fat was kidney fat and the kid fat was a mixed fat obtained from all parts of the carcass, and as has been previously noted,[2] the nature of fat varies somewhat with the part of the body from which it is taken. Though a little lower it compares very favorably in digestibility with goat's butter which was 99 per cent digested. The average amount of kid fat eaten daily, 62 grams, was somewhat in excess of 53 grams, the average daily consumption of mutton fat.

In the reports of their physical condition during the test period, none of the subjects made any mention of any laxative effect or other digestive disturbances resulting from the experimental diet, and accordingly on the basis of the experiments here reported, it may be assumed that kid fat, when eaten in amounts not in excess of 60

[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.
[2] U. S. Dept. Agr. Bul. 507 (1917), p. 9.

grams daily is quite well assimilated and is suited for use as human food.

HARD-PALATE FAT.

The so-called "hard palates" are taken from the roof of the mouth of beef animals. In appearance they are very unattractive, possessing a black or white, rough, ribbed outer surface, and contain little muscular tissue. According to information obtained from the Bureau of Animal Industry,[1] several of the large packing establishments utilize the hard palates of cattle in the preparation of edible products, such as potted meats, sausage, etc. One establishment is reported as saving about 2,500 pounds monthly, another about 6,000 pounds monthly. In view of this rather extensive use of hard palates for food purposes, it appeared very desirable to ascertain the digestibility of this material, and accordingly seven experiments were conducted in this laboratory, and it was found that the protein was approximately 87 per cent digested.[2] Some attention was paid also to the fat of the hard palates, and its possible uses for culinary purposes emphasized the desirability of studying its digestibility.

In the preparation of the hard palates for use in the experiments referred to they were boiled for two to three hours, a yellow fat being extracted during the process. While hard palates contain only a small amount of this fat—about 11 per cent—of which approximately one-half is extracted by boiling the hard palates for two or three hours, the total yield of packing houses preparing two or three tons per month of hard palates for edible purposes is evidently of commercial importance.

The hard-palate fat used in this study was obtained by boiling palates for two or three hours in a large amount of water. About 100 pounds of fresh hard palates secured from a local abattoir were extracted in this manner. The fat, which floated to the top of the liquor, hardened on cooling and was removed and purified by remelting several times in boiling water. It had a yellow color, was without characteristic taste, and resembled butter somewhat in appearance, though it was more granular.

As previously reported,[3] it was found to have a melting point of 34° C., an iodin number of 52.53, and a refractive index of 1.4586.

Three subjects assisted in the study of this fat. The results of the tests are reported in the following tables:

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[1] Personal communication.

[2] Digestibility of Hard Palates of Cattle, Jour. Agr. Research, 6 (1916), No. 17.

[3] Loc. cit.

Data of digestion experiments with hard-palate fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash
Experiment No. 574, subject A. J. H.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing hard-palate fat	1,329.0	522.8	24.1	201.7	569.1	11.3
Wheat biscuit	87.0	7.8	9.2	1.3	67.3	1.4
Fruit	305.0	265.1	2.4	0.6	35.4	1.5
Sugar	65.0				65.0	
Total food consumed	1,786.0	795.7	35.7	203.6	736.8	14.2
Feces	75.0		25.7	22.8	18.8	7.7
Amount utilized			10.0	180.8	718.0	6.5
Per cent utilized			28.0	88.8	97.4	45.8
Experiment No. 575, subject P. K.:						
Blancmange containing hard-palate fat	1,924.0	756.9	34.8	292.1	823.9	16.3
Wheat biscuit	357.0	32.1	37.8	5.4	276.0	5.7
Fruit	861.0	748.2	6.9	1.7	99.9	4.3
Sugar	69.0				69.0	
Total food consumed	3,211.0	1,537.2	79.5	299.2	1,268.8	26.3
Feces	82.0		26.0	27.2	20.2	8.6
Amount utilized			53.5	272.0	1,248.6	17.7
Per cent utilized			67.3	90.9	98.4	67.3
Experiment No. 576, subject C. J. W.:						
Blancmange containing hard-palate fat	1,949.0	766.7	35.3	295.9	834.5	16.6
Wheat biscuit	341.0	30.7	36.1	5.1	263.6	5.5
Fruit	1,011.0	878.6	8.1	2.0	117.3	5.0
Sugar	81.0				81.0	
Total food consumed	3,382.0	1,676.0	79.5	303.0	1,296.4	27.1
Feces	110.0		33.9	25.2	37.1	13.8
Amount utilized			45.6	277.8	1,259.3	13.3
Per cent utilized			57.4	91.7	97.1	49.1
Average food consumed per subject per day	931.0	445.5	21.6	89.5	366.9	7.5

Summary of digestion experiments with hard-palate fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of hard-palate fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574	A. J. H.	28.0	88.8	97.4	45.8	92.4
575	P. K.	67.3	90.9	98.4	67.3	93.5
576	C. J. W.	57.4	91.7	97.1	49.1	95.2
Average		50.9	90.5	97.6	54.1	93.7

It will be noted on referring to the above tables that the subjects ate on an average 22 grams of protein, 90 grams of fat, and 367 grams of carbohydrate daily, which had a fuel value of 2,366 calories. The protein, fat, and carbohydrate supplied by the total diet were 50.9 per cent, 90.5 per cent, and 97.6 per cent digested, respectively. When corrections are made for the metabolic products and undigested fat resulting from the basal ration occurring in the feces the value, 90.5

per cent, for the digestibility of the total fat of the diet becomes 93.7 per cent for the digestibility of the hard-palate fat.

The subjects all reported that they were in normal physical condition during the period of these experiments, and accordingly it appears that hard-palate fat of good quality may be eaten as a constituent of a simple mixed diet at least in amounts not exceeding 90 grams daily without physiological disturbances.

HORSE FAT.

At present horse flesh is sold for human food in this country in only a few of the larger cities. That the supply of animals exceeds the demand[1] is shown by letters received by commission firms in Chicago from Montana ranchmen offering in carload lots animals that were "overaged," "wire cut," "undersized," and "inbred," but in "good flesh and health." Horse flesh is quite generally used for human food in some European countries, for it is reported[2] that as long ago as 1892 in Paris and Vienna over 20,000 horses were slaughtered for human food. "Similar statistics are furnished also from Berlin and other public abattoirs in Prussia, and the supply of horse flesh as a meat food for the public has become a regular and well-organized business." In 1910, 29,000,000 pounds of horse meat[3] was produced for consumption in Paris and its environs. In Germany, in 1909, 152,214 horses were slaughtered, which provided 79.000,000 pounds of meat; approximately 1½ pounds per capita.

It is apparent from these statements that horse fat as a part of the meat enters into the European dietary. It is evidently also known as a separated fat, for Lewkowitsch[4] reports that "it is used by the poorer classes on the Continent as an edible fat in the place of lard, and is no doubt used as an adulterant of more expensive fats." There is a tradition in some foreign countries that it has a special value as shortening in pastry making.

Though no definite information regarding its use for such purposes in the United States has been found, it seemed not without interest to include a study of horse fat, and in order that the results obtained might be directly comparable with those obtained for beef, mutton, and pork (kidney fats), reported in an earlier paper,[5] an attempt was made to secure a supply of horse-kidney fat. However, after several horses had been slaughtered without securing from any sufficient kidney fat for the purpose of this study, it was decided to study a

[1] Nat. Provisioner, 58 (1918), No. 16, p. 17.
[2] Lancet [London], 1 (1918), No. 5, p. 189.
[3] Jour. Amer. Vet. Med. Assoc., n. ser., 4 (1917), No. 5, p. 681.
[4] Chemical Technology and Analysis of Oils, Fats, and Waxes, II. J. Lewkowitsch, London: Macmillan and Co. (1909), j. 547.
[5] U. S. Dept. Agr. Bul. 310 (1915).

composite fat taken from different parts of the body. Through the courtesy of Superintendent Hollister, of the National Zoological Park, a supply of horse fat (neck and leaf) was secured from a healthy inspected animal, such as are regularly procured to supply food for the carnivorous animals confined in the park. In the unrendered form its physical appearance was so similar to that of beef fat that the members of the laboratory staff who were unaware of its source assumed it to be beef fat. Samples of the neck and leaf fats which were analyzed by R. H. Kerr, of the Bureau of Animal Industry, were found to have the following constants: Neck fat, iodin number 95.83 and refractive index at 40° C. 55.5° and leaf fat, iodin number 91.22 and refractive index at 40° C. 54.0°. The unrendered fats were passed through a meat cutter, uniformly mixed, and rendered in a double boiler. The rendered fat on standing tended to separate into an oily and solid layer, resembling chicken fat in this respect.

Three subjects assisted in the experiments, which are reported in the tables which follow:

Data of digestion experiments with horse fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 747, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing horse fat	1,634.0	734.2	33.0	184.0	669.1	13.7
Wheat biscuit	304.0	27.4	32.2	4.5	235.0	4.9
Fruit	514.0	446.7	4.1	1.0	59.6	2.6
Sugar	265.0	.....	.....	.....	265.0	.....
Total food consumed	2,717.0	1,208.3	69.3	189.5	1,228.7	21.2
Feces	67.0	.....	22.3	9.4	29.9	5.4
Amount utilized	.....	.....	47.0	180.1	1,198.8	15.8
Per cent utilized	.....	.....	67.8	95.0	97.6	74.5
Experiment No. 748, subject M. L. M.:						
Blancmange containing horse fat	1,670.0	750.3	33.7	188.1	683.9	14.0
Wheat biscuit	558.0	50.2	59.2	8.4	431.3	8.9
Fruit	667.0	579.6	5.4	1.3	77.4	3.3
Sugar	429.0	.....	.....	.....	429.0	.....
Total food consumed	3,324.0	1,380.1	98.3	197.8	1,621.6	26.2
Feces	133.0	.....	40.8	13.2	68.3	10.7
Amount utilized	.....	.....	57.5	184.6	1,553.3	15.5
Per cent utilized	.....	.....	58.5	93.3	95.8	59.2
Experiment No. 749, subject J. C. M.:						
Blancmange containing horse fat	1,719.0	772.4	34.7	193.6	703.9	14.4
Wheat biscuit	385.0	34.6	40.8	5.8	297.6	6.2
Fruit	948.0	823.8	7.6	1.9	110.0	4.7
Sugar	194.0	.....	.....	.....	194.0	.....
Total food consumed	3,246.0	1,630.8	83.1	201.3	1,305.5	25.3
Feces	123.0	.....	37.4	15.3	59.8	10.5
Amount	.....	.....	45.7	186.0	1,245.7	14.8
Per cent utilized	.....	.....	55.0	92.4	95.4	58.5
Average food consumed per subject per day	1,032.0	468.8	27.9	65.4	461.8	8.1

Summary of digestion experiments with horse fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of horse fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
747	P. K.	67.8	95.0	97.6	74.5	95.2
748	M. L. M.	58.5	93.3	95.8	59.2	93.7
749	J. C. M.	55.0	92.4	95.4	58.5	92.7
Average		60.4	93.6	96.3	64.1	93.9

The fat-rich blancmange containing horse fat formed the predominating part of a simple mixed diet and was eaten without comment, indicating that this blancmange was as acceptable as that served in other experiments of a similar nature. All the subjects stated, in the reports which they submitted regarding their physical condition during the experimental period, that they continued in normal health.

On an average the subjects ate 28 grams of protein, 65 grams of fat, and 462 grams of carbohydrate daily, which supplied 2,545 calories of energy. The coefficients of digestibility of the diet as a whole were for protein 60.4 per cent, for fat, 93.6 per cent, and for the carbohydrate 96.3 per cent. If correction for the metabolic products and undigested basal ration fat is applied to the figure 93.6 per cent, the digestibility of the total fat of the diet, it is found that the coefficient of digestibility of horse fat alone is 93.9 per cent. This figure, 93.9 per cent, is for dietetic purposes the same as 93 per cent reported [1] in an earlier paper for the digestibility of beef-kidney fat. It is higher than the digestibility reported from similar experiments with mutton-kidney fat [1] (88 per cent), and somewhat lower than the digestibility of lard [1] (97 per cent), butter [1] (97 per cent), and beef-brisket fat [2] (97.4 per cent).

On the basis of these experiments it appears that rendered horse fat obtained from healthy animals when eaten as a part of a simple mixed diet in amounts not exceeding 65 grams daily produces no physiological disturbances and was well utilized by the human body.

OLEO OIL.

Beef tallow, like other edible fats, consists essentially of olein, palmitin, and stearin. In order to utilize most efficiently the enormous quantities of beef tallow that result from the slaughter of cattle in this country yearly, it has been found satisfactory to separate the beef tallow into soft (oleo oil) and hard (oleo stearin) fats. The

[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.
[2] U. S. Dept. Agr. Bul. 507 (1917), p. 18.

commercial manufacture of oleo oil and oleo stearin is, in brief, as follows: The rough fat from the slaughtered animal is washed with warm water, hardened naturally or by immersing in ice water. The hardened fat is finely cut, rendered in tin-lined jacketed vessels, and allowed to stand for a time in a crystallizing room, the temperature of which is carefully regulated, after which it is subjected to hydraulic pressure. The soft oleo oil runs out of the press and the hard oleo stearin remains in the press. Though they have very extensive commercial uses, oleo oil and oleo stearin are little known to the housekeeper.

While both the oleo oil and oleo stearin are used as constituents of compounded fats, designed for table and culinary purposes, oleo oil is also used as a separated fat by persons who, because of national or religious customs, prefer it to other types of animal fats. Oleo oil is also used in large quantities in the manufacture of oleomargarin.

The oleo oil which was studied in the experiments here reported was obtained from a dealer in edible fats and was held to be representative of commercial oleo oil. In appearance it was a light yellow fat of about the same consistency as butter, solid at ordinary room temperature, and without distinctive odor or taste.

The results which were obtained with oleo oil are included in the following tables:

Data of digestion experiments with oleo oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 805, subject J. F. C.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing oleo oil	1,125.0	500.7	19.7	146.8	449.2	8.6
Wheat biscuit	377.0	33.9	40.0	5.7	291.4	6.0
Fruit	1,316.0	1,143.6	10.5	2.6	152.7	6.6
Sugar	310.0	.....	.....	.....	310.0	.....
Total food consumed	3,128.0	1,678.2	70.2	155.1	1,203.3	21.2
Feces	88.0	.....	23.8	13.3	43.1	7.8
Amount utilized	.....	.....	46.4	141.8	1,160.2	13.4
Per cent utilized	.....	.....	66.1	91.4	96.4	63.4
Experiment No. 806, subject T. G. H.:						
Blancmange containing oleo oil	1,482.0	659.6	25.9	193.4	591.8	11.3
Wheat biscuit	84.0	7.6	8.9	1.3	64.9	1.3
Fruit	1,468.0	1,275.7	11.8	2.9	170.3	7.3
Sugar	199.0	.....	.....	.....	199.0	.....
Total food consumed	3,233.0	1,942.9	46.6	197.6	1,026.0	19.9
Feces	123.0	.....	35.4	24.9	52.3	10.4
Amount utilized	.....	.....	11.2	172.7	973.7	9.5
Per cent utilized	.....	.....	24.0	87.4	94.9	47.7

Data of digestion experiments with oleo oil in a simple mixed diet[a]—Continued.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 807, subject P.K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing oleo oil	1,201.0	534.6	21.0	156.7	479.6	9.1
Wheat biscuit	300.0	27.0	31.8	4.5	231.9	4.8
Fruit	291.0	252.9	2.3	.6	33.7	1.5
Sugar	293.0	.....	.....	.....	293.0	.....
Total food consumed	2,085.0	814.5	55.1	161.8	1,038.2	15.4
Feces	63.0	.....	18.2	14.7	23.4	6.7
Amount utilized	.....	.....	36.9	147.4	1,013.8	8.7
Per cent utilized	.....	.....	67.0	90.9	97.7	56.5
Experiment No. 808, subject G. S. M.:						
Blancmange containing oleo oil	1,368.0	608.9	23.9	178.5	546.3	10.4
Wheat biscuit	346.0	31.1	36.7	5.2	267.5	5.5
Fruit	1,350.0	1,173.1	10.8	2.7	156.6	6.8
Sugar	415.0	.....	.....	.....	415.0	.....
Total food consumed	3,479.0	1,813.1	71.4	186.4	1,385.4	22.7
Feces	152.0	.....	42.0	15.2	81.5	13.3
Amount utilized	.....	.....	29.4	171.2	1,303.9	9.4
Per cent utilized	.....	.....	41.2	91.8	94.1	41.4
Experiment No. 809, subject D. D. M.:						
Blancmange containing oleo oil	1,366.0	608.0	23.9	178.3	545.4	10.4
Wheat biscuit	623.0	56.1	66.0	9.3	481.6	10.0
Fruit	1,310.0	1,138.4	10.5	2.6	152.0	6.5
Sugar	414.0	.....	.....	.....	414.0	.....
Total food consumed	3,713.0	1,802.5	100.4	190.2	1,593.0	26.9
Feces	128.0	.....	37.3	14.2	65.1	11.4
Amount utilized	.....	.....	63.1	176.0	1,527.9	15.5
Per cent utilized	.....	.....	62.8	92.5	95.9	57.6
Experiment No. 810, subject M. L. M.:						
Blancmange containing oleo oil	1,267.0	563.9	22.2	165.4	505.9	9.6
Wheat biscuit	366.0	32.9	38.8	5.5	282.9	5.9
Fruit	1,152.0	1,001.1	9.2	2.3	133.6	5.8
Sugar	401.0	.....	.....	.....	401.0	.....
Total food consumed	3,186.0	1,597.9	70.2	173.2	1,323.4	21.3
Feces	99.0	.....	33.7	14.6	42.0	8.7
Amount utilized	.....	.....	36.5	159.6	1,281.4	12.6
Per cent utilized	.....	.....	52.0	91.6	96.8	59.2
Experiment No. 811, subject J. C. M.:						
Blancmange containing oleo oil	1,162.0	517.2	20.3	151.7	464.0	8.8
Wheat biscuit	426.0	38.3	45.2	6.4	329.3	6.8
Fruit	1,243.0	1,080.2	9.9	2.5	144.2	6.2
Sugar	135.0	.....	.....	.....	135.0	.....
Total food consumed	2,966.0	1,635.7	75.4	160.6	1,072.5	21.8
Feces	93.0	.....	24.3	15.2	43.2	10.3
Amount utilized	.....	.....	51.1	145.4	1,029.3	11.5
Per cent utilized	.....	.....	67.8	90.5	96.0	52.8
Experiment No. 812, subject W. O'C.:						
Blancmange containing oleo oil	1,476.0	657.0	25.8	192.6	589.4	11.2
Wheat biscuit	191.0	17.2	20.2	2.9	147.6	3.1
Fruit	1,125.0	977.6	9.0	2.3	130.5	5.6
Sugar	467.0	.....	.....	.....	467.0	.....
Total food consumed	3,259.0	1,651.8	55.0	197.8	1,334.5	19.9
Feces	119.0	.....	32.1	25.0	48.4	13.5
Amount utilized	.....	.....	22.9	172.8	1,286.1	6.4
Per cent utilized	.....	.....	41.6	87.4	96.4	32.2
Average food consumed per subject per day	1,043.7	539.0	22.7	59.3	415.7	7.0

Summary of digestion experiments with oleo oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of oleo oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
805	J. F. C.	66.1	91.4	96.4	63.4	96.9
806	T. G. H.	24.0	87.4	94.9	47.7	93.4
807	P. K.	67.0	90.9	97.7	56.5	94.6
808	G. S. M.	41.2	91.8	94.1	41.4	99.9
809	D. D. M.	62.8	92.5	95.9	57.6	99.1
810	M. L. M.	52.0	91.6	96.8	59.2	97.1
811	J. C. M.	67.8	90.5	96.0	52.8	96.0
812	W. O'C.	41.6	87.4	96.4	32.2	97.2
Average		52.8	90.4	96.0	51.4	96.8

The subjects ate on an average 23 grams of protein, 59 grams of fat, and 416 grams of carbohydrate daily. The digestibility of these food constituents was found to be 52.8 per cent for protein, 90.4 per cent for fat, and 96 per cent for carbohydrate. The estimated digestibility of oleo oil alone was 96.8 per cent, which is somewhat higher than the digestibility (93 per cent) previously reported for beef tallow,[1] which contains the oleo stearin as well as the oleo oil.

The subjects reported no ill effects from the test periods with oleo oil. The coefficient of digestibility of oleo oil, 96.8 per cent, as obtained in the above experiments, is practically identical with the reported[2] coefficients of digestibility of the common animal and vegetable fats, which, on the average, are 97 per cent.

OLEO STEARIN.

Oleo stearin, which is obtained as outlined above, is ordinarily a white, odorless, tasteless fat, solid at ordinary room temperature. It is quite extensively used in the manufacture of compounded edible fats commonly known as lard substitutes and lard compounds, but has relatively little if any use in the home as such for culinary purposes.

A supply of oleo stearin sufficient for the purpose of this study was obtained from a dealer who was able to supply it in quantity, and it was known to be typical of commercial oleo stearin.

Three experiments were made to determine the digestibility of oleo stearin, and the data obtained are tabulated on page 16.

[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

[2] See list on page 26.

Data of digestion experiments with oleo stearin in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 825, subject J. F. C.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing oleo stearin	1,164.0	528.3	20.4	198.6	410.9	5.8
Wheat biscuit	278.0	25.0	29.5	4.2	214.9	4.4
Fruit	856.0	743.9	6.8	1.7	99.3	4.3
Sugar	142.0	.....	.....	.....	142.0	.....
Total food consumed	2,440.0	1,297.2	56.7	204.5	867.1	14.5
Feces	153.0	.....	33.6	61.6	44.5	13.3
Amount utilized	.....	.....	23.1	142.9	822.6	1.2
Per cent utilized	.....	.....	40.7	69.9	94.9	8.3
Experiment No. 827, subject T. G. H.:						
Blancmange containing oleo stearin	1,012.0	459.3	17.7	172.7	357.2	5.1
Wheat biscuit	39.0	3.5	4.1	0.6	30.2	0.6
Fruit	617.0	536.2	4.9	1.2	71.6	3.1
Sugar	167.0	.....	.....	.....	167.0	.....
Total food consumed	1,835.0	999.0	26.7	174.5	626.0	8.8
Feces	92.0	.....	17.0	36.7	31.7	6.6
Amount utilized	.....	.....	9.7	137.8	594.3	2.2
Per cent utilized	.....	.....	36.3	79.0	94.9	24.7
Experiment No. 828, subject F. K.:						
Blancmange containing oleo stearin	1,317.0	597.8	23.0	224.7	464.9	6.6
Wheat biscuit	467.0	42.0	49.5	7.0	361.0	7.5
Fruit	791.0	687.4	6.3	1.6	91.8	3.9
Sugar	176.0	.....	.....	.....	176.0	.....
Total food consumed	2,751.0	1,327.2	78.8	233.3	1,093.7	18.0
Feces	199.0	.....	43.8	78.4	61.7	15.1
Amount utilized	.....	.....	35.0	154.9	1,032.0	2.9
Per cent utilized	.....	.....	44.4	66.4	94.4	16.6
Average food consumed per subject per day	780.6	402.6	18.0	68.0	281.8	4.6

Summary of digestion experiments with oleo stearin in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of oleo stearin alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
825	J. F. C.	40.7	69.9	94.9	8.3	76.6
827	T. G. H.	36.3	79.0	94.9	24.7	89.8
828	F. K.	44.4	66.4	94.4	16.6	73.9
Average		40.5	71.8	94.7	16.5	80.1

On an average the daily diet supplied 18 grams protein, 68 grams fat, and 281.8 grams carbohydrate, the energy value being 1,811 calories.

Considering the digestibility of the ration as a whole on an average the subjects digested 40.5 per cent of the protein, 71.8 per cent of the fat, and 94.7 per cent of the carbohydrate. The estimated digestibility of the oleo stearin alone is 80.1 per cent. The figure, as would naturally be expected, is considerably lower than that of oleo oil,

96.7 per cent, and also lower than 93 per cent, the digestibility of beef tallow, which consists of both oleo oil and oleo stearin.

In their reports of their physical condition during the test period, the subjects noted no unusual physiological conditions.

OX-MARROW FAT.

It is believed by many people that bone marrow possesses properties which make it of particular value for food purposes and of especial value in the dietary of invalids and convalescents. That there is a scientific basis for such belief is shown by a review of the literature. In discussing the value of fat in the diet Friedenwald and Ruhrah[1] say that bone marrow, which is rich in fat, is used in the treatment of tuberculosis and pernicious anemia. The marrow of young animals is preferred, and the glycerin extract of bone marrow is utilized. Zink[2] states: "Yellow marrow contains chiefly fat which consists of olein, palmitin, and stearin, and which differs from the fat of the other parts of the body in having a higher acetyl equivalent." In a study of red marrow Forrest[3] obtained two proteins, one a globulin coagulating at 47–50° C., which contained no phosphorus, and a second a nucleo-albumin which was found to contain phosphorus in its molecule. Glikin[4] reports that iron occurs regularly in beef marrow, the marrow of young animals containing larger amounts than that of old animals. According to Halliburton[5] the most important protein of red marrow "is a nucleo-protein which contains 1.6 per cent of phosphorus." In considering the dietary value of marrow, however, it must be remembered that it contains a large amount of marrow fat and that this, like all other fats, is a valuable source of energy in addition to the special therapeutic value attributed to it. Marrow is well known as food. Common examples are marrow bones, an old-fashioned dish, and marrow balls, which are served in soup.

The preparation of marrow fat is confined very largely to the packing houses, where it is obtained from the leg bones of beef animals. The process, according to information obtained from the Bureau of Animal Industry, is as follows:

Marrow fat is prepared from long or shank bones, they being first heated in water at a temperature of from 160° to 170° Fahrenheit. Both ends of the bones are sawed off and the marrow removed by blowing with compressed air.

[1] Diet in Health and Disease. Philadelphia and London: W. B. Saunders Co., 1913, 4. ed., p. 144.
[2] Chem. Zentbl., 68 (1897), No. 5, p. 296.
[3] Jour. Physiol., 17 (1894–5), p. 175.
[4] Ber. Deut. Chem. Gesell., 41 (1908), No. 5, p. 910.
[5] Jour. Physiol., 18 (1895), No. 4, pp. 306–318.

It is placed in cans, being processed in the usual manner for processing canned meat products. When prepared in this manner it is put out in the trade as "ox marrow."

For the purpose of this study a supply of this fat, packed in 1-pound tins labeled "Ox-Marrow Fat," was obtained from commercial sources. In appearance it was of a yellow color, solid at room temperature, and without a characteristic odor. The fat was melted, thoroughly mixed, and a sample analyzed by R. H. Kerr, of the Bureau of Animal Industry, was found to have an iodin number of 48.48, refractive index of 47°, with a Zeiss butyro-refractometer at 40°, and 0.56 per cent of free acid.

The marrow fat was incorporated in a blancmange and eaten as a constituent of the usual simple mixed diet by four subjects. The results of the experiments are reported in the following tables:

Data of digestion experiments with ox-marrow fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 692, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing ox-marrow fat	1,700.0	710.1	30.8	294.8	651.1	13.2
Wheat biscuit	305.0	27.4	32.3	4.6	235.8	4.9
Fruit	418.0	363.2	3.4	0.8	48.5	2.1
Sugar	136.0	.....	.....	.....	136.0	.....
Total food consumed	2,559.0	1,100.7	66.5	300.2	1,071.4	20.2
Feces	76.0	.....	21.1	26.0	23.2	5.7
Amount utilized	.....	.....	45.4	274.2	1,048.2	14.5
Per cent utilized	.....	.....	68.3	91.3	97.8	71.8
Experiment No. 693, subject J. C. M.:						
Blancmange containing ox-marrow fat	1,928.0	805.3	34.9	334.3	738.4	15.1
Wheat biscuit	371.0	33.4	39.3	5.6	286.8	5.9
Fruit	796.0	691.7	6.4	1.6	92.3	4.0
Sugar	122.0	.....	.....	.....	122.0	.....
Total food consumed	3,217.0	1,530.4	80.6	341.5	1,239.5	25.0
Feces	83.0	.....	24.8	22.9	27.5	7.8
Amount utilized	.....	.....	55.8	318.6	1,212.0	17.2
Per cent utilized	.....	.....	69.2	93.3	97.8	68.8
Experiment No. 694, subject A. A. R.:						
Blancmange containing ox-marrow fat	1,793.0	748.9	32.5	310.9	686.7	14.0
Wheat biscuit	118.0	10.6	12.5	1.8	91.2	1.9
Fruit	1,246.0	1,082.8	10.0	2.5	144.5	6.2
Sugar	122.0	.....	.....	.....	122.0	.....
Total food consumed	3,279.0	1,842.3	55.0	315.2	1,044.4	22.1
Feces	108.0	.....	37.7	28.7	31.9	9.7
Amount utilized	.....	.....	17.3	286.5	1,012.5	12.4
Per cent utilized	.....	.....	31.5	90.9	96.9	56.1
Experiment No. 695, subject W. E. T.:						
Blancmange containing ox-marrow fat	588.0	245.6	10.6	102.0	225.2	4.6
Wheat biscuit	313.0	28.2	33.2	4.7	241.9	5.0
Fruit	989.0	859.4	7.9	2.0	114.7	5.0
Sugar	138.0	.....	.....	.....	138.0	.....
Total food consumed	2,028.0	1,133.2	51.7	108.7	719.8	14.6
Feces	56.0	.....	16.6	11.6	20.5	7.3
Amount utilized	.....	.....	35.1	97.1	699.3	7.3
Per cent utilized	.....	.....	67.9	89.3	97.2	50.0
Average food consumed per subject per day	923.6	467.2	21.2	88.8	339.6	6.8

Summary of digestion experiments with ox-marrow fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of ox-marrow fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
692	P. K.	68.3	91.3	97.8	71.8	93.7
693	J. C. M.	69.2	93.3	97.8	68.8	95.6
694	A. A. R.	31.5	90.9	96.9	56.1	91.6
695	W. E. T.	67.9	89.3	97.2	50.0	93.1
Average		59.2	91.2	97.4	61.7	93.5

In the experiments reported above the subjects ate on an average 21 grams of protein, 89 grams of fat (of which 87 grams were marrow fat), and 340 grams of carbohydrate. This diet furnished approximately 2,245 calories of energy daily. It will be noted that in experiment No. 695 the subject W. E. T., who did not possess a very vigorous appetite, ate only 109 grams of fat during the three-day period. The other subjects averaged 104 grams of fat daily. The protein supplied by the diet was 59.2 per cent digested, the fat 91.2 per cent, and the carbohydrate 97.4 per cent. The figure 91.2 per cent for the digestibility of the total fat of the diet becomes 93.5 per cent for the digestibility of marrow fat alone when correction is applied for the metabolic products and undigested basal-ration fat which occurs in the ether extract of the feces.

The consumption of 100 grams of marrow fat daily for a period of three days or more evidently caused digestive disturbances since in experiment No. 692, subject P. K. reported: "Health was normal when entering on the diet. During the period experienced a slight headache and a sickish feeling." In experiment No. 693, subject J. C. M. reported: "Felt a severe weakness accompanied by cold perspiration." In experiment No. 694, subject A. A. R. reported: "Pains in head and abdomen, general feeling of weakness." In experiment No. 695, subject W. E. T. reported: "Health normal at start of diet, during diet headache with general weak feeling."

On the basis of these experiments alone, it would appear that the continued consumption of 100 grams of marrow fat daily is likely to be attended with physiological disturbances. The results of the experiments indicate, however, that this fat is as completely digested as the common animal and vegetable fats.

OX-TAIL FAT.

Ox-tail fat is separated and marketed as an edible fat to a small extent at least in this country. In reply to an inquiry regarding its commercial production, one food-packing concern states: "This fat

is not a by-product with us, but is used in the preparation of our ox-tail soup. We have absolutely no means of estimating the quantities of this fat produced in this country." A second concern reports: "We produce considerable quantities ourselves, some of which we use and some of which we sell. It is more liquid than other beef fats, containing less stearin, and for this reason would be better adapted to the manufacture of oleo oil. We sell it as an edible fat, and so far as we know, it is used with other beef fats as a shortening or for other food purposes."

Even if little of the fat is marketed for food purposes, it is evident that it is not uncommonly so used when one recalls that it is a constituent of freshly made and canned ox-tail soup.

For the purpose of this study a sufficient quantity of ox-tail fat was secured from a concern which did not include the ox-tail fat in the ox-tail soup which it packed. In appearance the fat was a cream white solid when chilled. At ordinary room temperature the fat separated into two layers, about four-fifths being a pale yellow solid and about one-fifth a light yellow oil. The fat possessed no pronounced odor or flavor. An examination [1] showed it to have the following characteristics: Index of refraction at 40° C., 49.0°; iodin number, 56.58; and melting point 37.0° to 36.8°.

Three subjects assisted in the study of the digestibility of ox-tail fat and the data obtained are reported in the tables which follow:

Data of digestion experiments with ox-tail fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 704, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing ox-tail fat	1,814.0	824.3	35.9	227.1	711.8	14.9
Wheat biscuit	302.0	27.2	32.0	4.5	233.5	4.8
Fruit	545.0	473.6	4.4	1.1	63.2	2.7
Sugar	251.0	.....	.....	.....	251.0	.....
Total food consumed	2,912.0	1,325.1	72.3	232.7	1,259.5	22.4
Feces	58.0	.....	17.8	13.7	21.0	5.5
Amount utilized	.....	.....	54.5	219.0	1,238.5	16.9
Per cent utilized	.....	.....	75.4	94.1	98.3	75.5
Experiment No. 705, subject J. C. M.:						
Blancmange containing ox-tail fat	2,004.0	910.6	39.7	250.9	786.4	16.4
Wheat biscuit	399.0	35.9	42.3	6.0	308.4	6.4
Fruit	825.0	716.9	6.6	1.7	95.7	4.1
Sugar	148.0	.....	.....	.....	148.0	.....
Total food consumed	3,376.0	1,663.4	88.6	258.6	1,338.5	26.9
Feces	86.0	.....	26.0	13.0	38.2	8.8
Amount utilized	.....	.....	62.6	245.6	1,300.3	18.1
Per cent utilized	.....	.....	70.7	95.0	97.2	67.3

[1] Analysis submitted by meat inspection laboratories of Bureau of Animal Industry.

Data of digestion experiments with ox-tail fat in a simple mixed diet—Contd.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 706, subject A. A. R.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing ox-tail fat	1,537.0	698.4	30.5	192.4	603.1	12.6
Wheat biscuit	244.0	21.9	25.9	3.7	188.6	3.9
Fruit	1,192.0	1,035.8	9.5	2.4	138.3	6.0
Sugar	118.0	.....	.....	.....	118.0	.....
Total food consumed	3,091.0	1,756.1	65.9	198.5	1,048.0	22.5
Feces	115.0	.....	14.7	20.2	69.4	10.7
Amount utilized	.....	.....	51.2	178.3	978.6	11.8
Per cent utilized	.....	.....	77.7	89.8	93.4	52.4
Average food consumed per subject per day	1,042.1	527.2	25.2	76.6	405.1	8.0

Summary of digestion experiments with ox-tail fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of ox-tail fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
704	P. K.	75.4	94.1	98.3	75.5	96.3
705	J. C. M.	70.7	95.0	97.2	67.3	98.2
706	A. A. R.	77.7	89.	93.4	52.4	95.4
Average	.....	74.6	93.0	96.3	65.1	96.6

The daily diet supplied on an average 25.2 grams protein, 76.6 grams fat, and 405.1 grams carbohydrate, the energy value being 2,411 calories.

The average digestibility of the diet as a whole was found to be 74.6 per cent for protein, 93 per cent for fat, and 96.3 per cent for carbohydrate when 25 grams of protein, 77 grams of fat, and 405 grams of carbohydrate were eaten daily. The estimated digestibility of ox-tail fat alone was found to be 96.6 per cent when the usual correction was made for the metabolic products and undigested basal-ration fat occurring in the ether extract of the feces.

In reports of their physical condition during the test period, the subjects made no reference to any laxative effect resulting from the diet, and accordingly it is assumed that the limit of tolerance for ox-tail fat is in excess of 84 grams daily, the amount eaten by one of the subjects, J. C. M., for the three-day test period.

In so far as these experiments are concerned, it would appear that ox-tail fat, which is quite completely digested and does not produce physiological disturbances when eaten in normal amounts, should

prove a satisfactory source of energy for the dietary whether eaten as a separate fat or as a constituent of ox-tail soup.

It has often been noted that fats from the different parts of the body possess different chemical and physical characteristics. In this connection it is interesting to note the values obtained for the digestibility of the different beef fats reported in this and other bulletins of this series which were for beef tallow [1] 93 per cent, beef-brisket fat [2] 97.4 per cent, hard-palate fat 93.7 per cent, ox-marrow fat 93.5 per cent, and ox-tail fat 96.6 per cent. These values would, of course, be more directly comparable had it been possible to secure a sufficient supply of these different fats from a single animal.

TURTLE FAT.

The flesh of the green turtle (*Chelonia mydas*), a sea turtle which lives mostly in deep water and feeds largely upon vegetable matter, is used considerably for food. The portion of the flesh known as "califash" adhering to the upper shell, has a high oil content, is of a dull greenish color, and is very highly prized, being used in the preparation of turtle soup. According to Ditmar [3] the name green turtle is due to the greenish color of the oil.

The experiments which follow were conducted to secure data concerning the extent to which green-turtle fat is utilized by the body. Through the courtesy of R. L. Coker of the United States Bureau of Fisheries, several cans of so-called turtle fat were secured from a Florida dealer. On opening, the cans were found to contain a dull greenish substance, the "califash," resembling liver in appearance, and surrounded by small quantities of a yellow oil which had separated from it. For the sake of uniformity with other experiments, the canned turtle fat was rendered and fed in the same way as other fats studied. In order to secure as much of the oil as possible, the mass was passed through an ordinary household meat cutter and was rendered by heating in a double boiler. The resulting oil was of a yellow color without any noticeable odor.

Four three-day digestion tests were made of green-turtle fat and the results which were obtained are reported in the tables which follow.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.
[2] U. S. Dept. Agr. Bul. 507 (1917), p. 18.
[3] Reptiles of the World. New York: Sturgis and Walton, p. 14.

Data of digestion experiments with green-turtle fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.			
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 681, subject A. F.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing green-turtle fat	1,933.0	890.0	34.0	174.2	821.7	13.1
Wheat biscuit	378.0	34.0	40.1	5.7	292.2	6.0
Fruit	657.0	570.9	5.3	1.3	76.2	3.3
Sugar	227.0	.....	.....	.....	227.0	.....
Total food consumed	3,195.0	1,494.9	79.4	181.2	1,417.1	22.4
Feces	73.0	.....	21.4	10.0	32.4	9.2
Amount utilized	.....	.....	58.0	171.2	1,384.7	13.2
Per cent utilized	.....	.....	73.0	94.5	97.7	58.9
Experiment No. 682, subject P. K.:						
Blancmange containing green-turtle fat	1,703.0	784.1	30.0	153.4	723.9	11.6
Wheat biscuit	338.0	30.4	35.8	5.1	261.3	5.4
Fruit	368.0	319.8	3.0	0.7	42.7	1.8
Sugar	164.0	.....	.....	.....	164.0	.....
Total food consumed	2,573.0	1,134.3	68.8	159.2	1,191.9	18.8
Feces	79.0	.....	26.3	11.6	34.3	6.8
Amount utilized	.....	.....	42.5	147.6	1,157.6	12.0
Per cent utilized	.....	.....	61.8	92.7	97.1	63.8
Experiment No. 683, subject J. C. M.:						
Blancmange containing green-turtle fat	1,377.0	634.0	24.2	124.1	585.4	9.3
Wheat biscuit	321.0	28.9	34.0	4.8	248.1	5.2
Fruit	780.0	677.8	6.2	1.6	90.5	3.9
Sugar	143.0	.....	.....	.....	143.0	.....
Total food consumed	2,621.0	1,340.7	64.4	130.5	1,067.0	18.4
Feces	105.0	.....	29.7	7.5	59.9	7.9
Amount utilized	.....	.....	34.7	123.0	1,007.1	10.5
Per cent utilized	.....	.....	53.9	94.2	94.4	57.1
Experiment No. 684, subject A. A. R.:						
Blancmange containing green-turtle fat	1,180.0	543.3	20.8	106.3	501.6	8.0
Wheat biscuit	159.0	14.3	16.9	2.4	122.9	2.5
Fruit	1,139.0	989.8	9.1	2.3	132.1	5.7
Sugar	396.0	.....	.....	.....	396.0	.....
Total food consumed	2,874.0	1,547.4	46.8	111.0	1,152.6	16.2
Feces	76.0	.....	27.3	9.1	32.4	7.2
Amount utilized	.....	.....	19.5	101.9	1,120.2	9.0
Per cent utilized	.....	.....	41.7	91.8	97.2	55.6
Average food consumed per subject per day	938.5	459.8	21.6	48.5	402.4	6.3

Summary of digestion experiments with green-turtle fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of green-turtle fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
681	A. F.	73.0	94.5	97.7	58.9	98.3
682	P. K.	61.8	92.7	97.1	63.8	97.5
683	J. C. M.	53.9	94.2	94.4	57.1	100.0
684	A. A. R.	41.7	91.8	97.2	55.6	98.4
Average	.....	57.6	93.3	96.6	58.9	98.6

On an average the four subjects who assisted in the study of the digestibility of turtle fat ate 22 grams of protein, 49 grams of fat, and 402 grams of carbohydrate daily. The digestibility of the diet as a whole was found to be, for protein 57.6 per cent, for fat, 93.3 per cent, and for carbohydrate, 96.6 per cent. When allowance is made for metabolic products and undigested fat resulting from the basal ration, the figure, 93.3 per cent, for the digestibility of the total fat of the diet, becomes 98.6 per cent for the digestibility of turtle fat alone. In reports of their physical condition the subjects made no reference to any laxative effect or other digestive disturbance resulting from the diet. Accordingly, it may be assumed that green-turtle fat taken in quantities not exceeding 50 grams daily is well tolerated and very completely assimilated by the body.

SUMMARY.

As a group the fats which are considered in the present paper are not extensively used in the home as separate fats, but all are included to a greater or less extent in the American dietary. Two of them, oleo oil and oleo stearin, find large commercial uses in the manufacture of fats for domestic consumption, oleo oil being used in the manufacture of oleomargarin and oleo stearin in the manufacture of shortening fats. Since little, if any, information was available regarding the extent to which they are utilized by the human body, their coefficients of digestibility were determined and found to be 98.4 per cent for goat's butter, 95.3 per cent for kid fat, 93.7 per cent for hard-palate fat, 93.9 per cent for horse fat, 96.8 per cent for oleo oil, 80.1 per cent for oleo stearin, 93.5 per cent for ox-marrow fat, 96.6 per cent for ox-tail fat, and 98.6 per cent for turtle fat.

The studies of the digestibility of fats here reported include four experiments with goat's butter, three experiments with kid fat, three experiments with hard-palate fat, three experiments with horse fat, eight experiments with oleo oil, three experiments with oleo stearin, four experiments with ox-marrow fat, three experiments with ox-tail fat, and four experiments with green-turtle fat.

The subjects ate per day on an average 42.8 grams of goat's butter, 59.7 grams of kid fat, 87.7 grams of hard-palate fat, 62.9 grams of horse fat, 56.8 grams of oleo oil, 66.2 grams of oleo stearin, 86.8 grams of ox-marrow fat, 74.5 grams of ox-tail fat, and 46.5 grams of turtle fat.

In the reports of their physical condition during the test periods, the subjects did not note any physiological disturbances except in the case of ox-marrow fat, which seemed to have a slight laxative effect. No evidence was secured as to whether this condition resulted

from the nature of the fat or from the fairly large amount ingested daily.

The protein and carbohydrate eaten during the test periods with the fats studied in these experiments were derived from the same foods as in the experiments reported in previous bulletins. The coefficients of digestibility for total protein were 72 per cent in the goat's butter tests, 88 per cent in the kid-fat tests, 50.9 per cent in the hard-palate fat tests, 60 per cent in the horse-fat tests, 52.8 per cent in the oleo-oil tests, 40.5 per cent in the oleo-stearin tests, 59 per cent in the ox-marrow fat tests, 75 per cent in the ox-tail fat tests, and 58 per cent in the turtle-fat tests. The coefficients of digestibility for total carbohydrate were 97.3 per cent in the goat's butter tests, 95 per cent in the kid-fat tests, 97.6 per cent in the hard-palate fat tests, 96 per cent in the horse-fat tests, 96.0 per cent in the oleo-oil tests, 94.7 per cent in the oleo-stearin tests, 97 per cent in the ox-marrow fat tests, 96 per cent in the ox-tail fat tests, and 97 per cent in the turtle-fat tests. The above coefficients of digestibility of protein and carbohydrate supplied by the diet as a whole indicate that the fats under consideration did not decrease the assimilation of these constituents.

On the basis of the experiments here reported it is evident that goat's butter, kid fat, hard-palate fat, horse fat, oleo oil, oleo stearin, ox-marrow fat, ox-tail fat, and turtle fat when eaten in amounts equivalent to the amount of butter eaten in the normal dietary are well assimilated, and judged by this and what is known of their use as food fats, should prove wholesome sources of fat for human consumption.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 614

OFFICE OF THE SECRETARY
Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C. ▼ April 20, 1918

COST OF PRODUCING APPLES IN YAKIMA VALLEY, WASHINGTON.[1]

A detailed study of the current cost factors involved in the maintenance of orchards and the handling of the crop on 120 representative bearing orchards.

By G. H. MILLER, *Assistant Agriculturist*, and S. M. THOMSON, *Scientific Assistant*.

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INTRODUCTION.

This bulletin presents the results of a study of apple orcharding in Yakima Valley (Washington) made by the Office of Farm Management during the summer of 1915. As with previous surveys conducted in the apple-growing districts of the Northwest, the object of the study was to determine the cost factors involved in apple production, and to gather such information as to the different methods of orchard management practiced by the growers of the valley as might have a bearing upon cost of production.

Data were obtained by the same method used in Wenatchee Valley in 1914. A sufficient number of orchardists were visited to give a reliable average, and complete and detailed information was gathered regarding the usual methods of procedure in orchard management,

[1] This is the fourth of a series of bulletins on the cost of apple production. Department Bulletin No. 446, "The Cost of Producing Apples in Wenatchee Valley, Washington," Department Bulletin No. 599, "The Cost of Producing Apples in Western Colorado," and Department Bulletin No. 518, "The Cost of Producing Apples in Hood River Valley," have already been published.

NOTE.—Acknowledgment is due to the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry for material assistance in the preparation of this bulletin; also to Mr. J. Clifford Folger, who aided in securing the necessary data, and Mr. F. E. De Sellem, Horticultural Inspector at Large, North Yakima, for helpful suggestions.

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including data on labor necessary for the annual upkeep of the orchard, on the care and harvesting of the crop, total investment, insurance, taxes, and all other expenses connected either directly or indirectly with production. One hundred and twenty records were taken.

Conditions prevailing in the Yakima Valley differ in some respects from those in any other of the important apple-producing regions of the Northwest. Two more or less distinct types of fruit farming are found. In the vicinity of the city of North Yakima is a highly specialized orcharding similar to that about Wenatchee, while in the lower valley, about the town of Zillah, there is a more diversified type of farming, with the growing of apples as one of several farm enterprises.

In this bulletin the acre is used as a basis of comparison. If the box were used as a unit, the figure for different districts might be misleading, since there might be a considerable variation in yield on orchards of the same size and age in different districts.

FACTS BROUGHT OUT.

Following is a brief summary of the more important facts brought out in this study of 120 bearing orchards in the Yakima Valley:

Average size of ranch:[1]

All records, 15.82 acres { North Yakima district (64 ranches), 10.79 acres. / Zillah district (56 ranches), 21.57 acres.

Average size of bearing orchard:

All records, 6.39 acres { North Yakima district, 5.18. / Zillah district, 7.77.

Average investment:

All records, per ranch, $14,504.32, of which $6,071.38 represents the bearing apple orchard.

All records, per acre of bearing apples, $1,079.87 { North Yakima district, $1,531.25. / Zillah district, $563.57.

Average annual yield:

All records { Per acre, 432 boxes. / Per tree, 5.87 boxes.

Average net cost per box:

All records, $0.8002 { Net labor cost, $0.3449. / Costs other than labor, $0.4553.

Average interest on investment:

All records, $0.1999 per box (75.9 per cent of fixed cost and 24.98 per cent of total net cost of production).

THE YAKIMA DISTRICT.

Yakima County is located in the south-central part of the State of Washington (see fig. 1). It is bounded on the west by the main range of the Cascade Mountains, which separates it from the counties of Pierce, Lewis, and Skamania; on the south by Klickitat County; on the east by Benton County and the Columbia River; and on the north by Kittitas County.

[1] The word "ranch" is a local term for any farm, and the word "rancher" is used in the sense of farmer.

The county contains a total of 2,622,760 acres, of which 742,082 are deeded. Of the latter acreage 187,084 are irrigable. In 1914 there were 47,829 acres in fruit, of which 41,955 acres, or 88 per cent, were in apples.[1] (See Table I.) Approximately the following acreages are in other fruits: Peach and apricot, 2,054; pear, 1,623; prune and plum, 279; cherry, 78; and mixed fruits, 1,840.

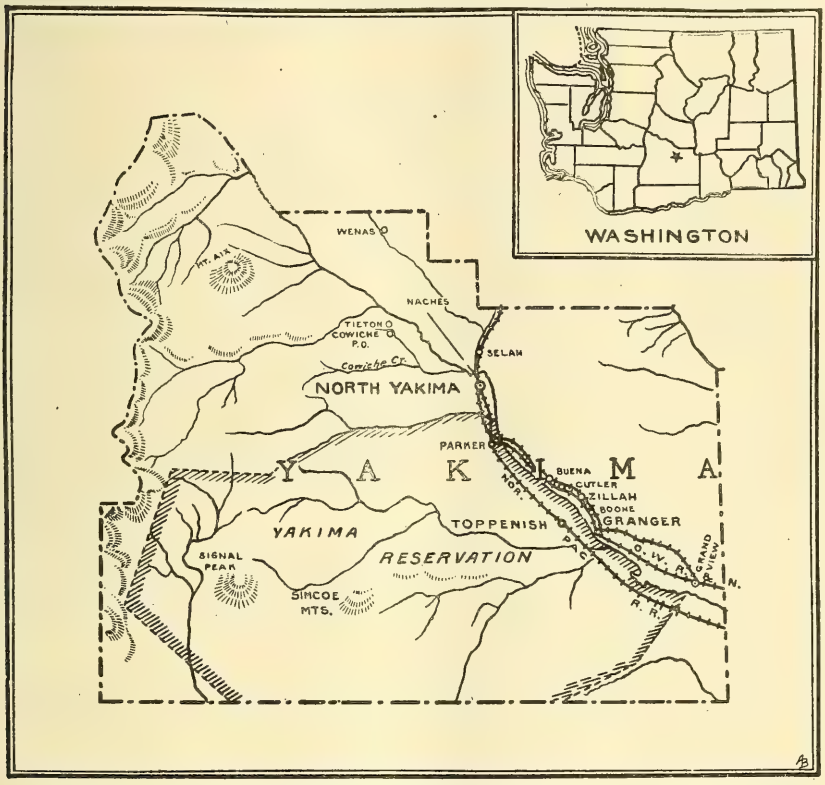


FIG. 1.—Outline map of Washington State and Yakima County, showing locations in the valley where the investigation was made.

TABLE I.—*Apple acreage at different ages in Yakima County.*

Age of trees.	Acreage.	Age of trees.	Acreage.
1 year	2,517	6 years	5,280
2 years	5,018	Bearing	8,528
3 years	8,000		
4 years	6,460	Total	41,955
5 years	6,152		

Fruit is grown throughout the entire valley. Extensive plantings of young orchards are found in the Tieton, Cowiche, Selah, and Naches areas, which lie north and west of North Yakima. (See Table II.) Older commercial plantings are found in the vicinity of North

[1] From the county assessor's report of the classification of lands in Yakima County, June, 1914. Since the report, about 2,000 acres of apple trees have been removed.

Yakima, Parker, Sawyer, Zillah, and Granger. Less intensive and somewhat younger plantings are found in the lower valley beyond Granger and as far down as Grandview.

This investigation was made principally in the vicinity of North Yakima and Zillah, where the older orchards are located.

The apple-producing areas visited near North Yakima are known locally as the Nob Hill, Broadway, and Fruitvale areas. The Zillah district lies in the lower valley about 20 miles southeast of North Yakima. This area extends from Buena to Boone and is most intensive in the vicinity of Cutler and Zillah.

IMPORTANCE OF THE APPLE IN YAKIMA COUNTY.

Yakima County has a larger acreage in fruit than any other county in the State. In 1914 there were 47,829 acres in fruit, of which 41,955 acres were in apples. Twenty per cent of this apple acreage was in bearing. More than 4,000 cars of apples were shipped from the county in 1912; 1,995 cars were shipped in 1913; 6,243 cars in 1914; 3,150 cars in 1915; and more than 7,000 cars in 1916. The bulk of fruit now produced comes from the vicinities of Nob Hill, Zillah, Reservation, Selah, Grandview, and Sunnyside, and in the near future the Selah, Cowiche, Tieton, Grandview, Wenas, and Naches areas bid fair to show a much greater production, these areas in 1914 containing 49 per cent of the total acreage of apples not yet in bearing in the county.

In some sections in the valley apple orchards are being eliminated and the lands put in other crops. The apple, however, is by far the most important commercial fruit in the county, 88 per cent of the total fruit acreage being in apples.

TABLE II.—*The principal fruit-producing areas of Yakima County, Washington, with the number of acres of different fruits in each.*[1]

County and areas.	Total acreage for—							
	Fruits.	Apples.	Bearing apples.	Peaches and apricots.	Pears.	Plums and prunes.	Cherries.	Mixed orchards.
Yakima County	47,829	41,955	8,528	2,054	1,623	279	78	1,840
Nob Hill	4,820	3,977	1,476	254	209	.....	7	373
Zillah	3,683	3,137	1,310	162	212	44	4	124
Selah	5,880	5,683	615	21	73	17	.....	86
Parker	3,250	1,898	268	789	319	189	12	43
Grandview	4,412	3,934	555	84	239	9	5	141
Cowiche and Tieton	3,973	3,845	76	27	28	.....	4	69
Sunnyside	1,578	1,402	496	67	77	1	.....	31
Upper and Lower Naches	3,532	3,305	432	37	77	.....	.....	113
Reservation	3,486	3,304	817	150	11	.....	.....	21

[1] From the county assessor's report of the classification of lands in Yakima County, June, 1914.

HISTORY AND DEVELOPMENT OF THE INDUSTRY.

A few white settlers came to Yakima Valley in the early sixties. The unlimited range encouraged stock raising; until the late eighties commercial fruit plantings were unknown to the valley. In the

seventies farmers began in a small way to practice irrigation, taking water from rivers and creeks to irrigate small tracts in the adjacent lowlands. Probably the first irrigating ditch of any size was the Konewoc, which was built about 1878. This ditch, some 9 miles long, tapped the Yakima River at a point about 10 miles below the present site of the city of North Yakima. The irrigated land was used for growing alfalfa and wheat hay, but only upon a very limited scale. A few hopyards were found in the Ahtanum Valley as early as 1880.

By 1888 there were a few family orchards in the district, mostly prunes and apples. Probably the first commercial planting of fruit trees was made about this time by H. J. Bicknell in what is known as Parker Bottom. This planting consisted of 3 acres, principally prunes and peaches. In the spring of 1889 Fred Thomson set out, also in the Parker Bottom district, the next commercial planting, including probably the first commercial apple orchard in the valley. His whole planting consisted of 10 acres, including 3 acres of prunes, 3 acres of peaches, 3 acres of Ben Davis apples, and 1 acre of pears. At this time a few express shipments of fruit were being sent to the coast cities from the small home orchards. The fine quality of the fruit and its freedom from insect injury and diseases were incentives to commercial planting, and following the early plantings in Parker Bottom other orchards were set near Zillah, a few miles below, and also in Naches, at Selah, and on Nob Hill in the upper valley.

In 1888 and 1889 two important irrigation companies were organized; one under John A. Stone to undertake the Selah project and the other under Paul Schulze to develop what is now known as the Sunnyside Government ditch. Land with water rights at this time was selling from $30 to $50 per acre. Paul Schulze was the Northern Pacific land agent and had purchased from this railroad a considerable acreage which it had received as a part of the alternate sections given under Government land grants. The other sections of land were open to homestead. Both the above companies went into the hands of receivers in 1893 and emerged as private corporations again about three years later. The Government purchased the Sunnyside Canal in 1906 and about 1911 the Selah project was taken over by the growers in the form of a water users' association. About 1896 the Government built a canal to the Indian reservation and in 1909 began the Tieton and other reservation canals. Following the Selah and Sunnyside projects came the Congdon or Yakima Valley Canal and also the Selah-Moxee Canal.

Up to about 1897 the prune-growing industry occupied a position of chief importance; about this time the prices for prunes became so low that many orchards were pulled out.

In 1894 the total apple output shipped from the valley probably amounted to about 25 carloads and was assembled from small home orchards. The fruit was layer packed but not wrapped. The old 60-pound box, 12 by 12 by 21 inches was in common use at that time. The apples were marketed chiefly in coast cities and netted the growers about $1.50 per box. In 1896 Mr. Fred Thompson shipped from the Yakima Valley what was probably its first car of fruit to be sold east of the Mississippi River. This car consisted chiefly of peaches and pears.

It was about 1894 that the apple-planting period really began. Reliable estimates place the total acreage of all orchard land at about 3,000 acres in 1900 and the total apple crop for that year at about 200 carloads. This output was nearly doubled in the next two years, during which time the early commercial plantings were coming into bearing. With this development of the fruit industry had come the growing of alfalfa, potatoes, and hops upon a fairly large scale.

Growers received in the neighborhood of $1.50 per box for apples during these times, and this high price brought on a very extensive planting of apples, which reached a climax about 1907 and 1908. The first varieties to be planted were principally Ben Davis, Winesap, Jonathan, Baldwin, and White Pearmain.

SOIL.

Yakima sandy loam occupies not only the principal portion of the Ahtanum Valley, where the investigations about North Yakima were made, but also the district in which Buena, Zillah, and Boone are located. This soil is typically a fine gray sandy loam, light and friable, and varies in depth from a few inches to 60 feet or more. It lends itself easily to cultivation and is well adapted to the crops which may be grown in this climate.

DISEASES AND PESTS.

Fire blight, both on the pear and apple, is a serious menace to the fruit industry of the valley. Many of the orchards suffered from the prevalence of this disease in 1912 and 1914. Considerable damage has been done each year and but for the efficient work of the county inspector and the organizations of the growers themselves a greater loss would have resulted.

Apple powdery-mildew has been found in all parts of the valley, affecting the Jonathan more than any other variety; but on the whole it has done little damage. Both iron sulphide and atomic sulphur have been used for its control. It is only within the last two years that it has caused valley-wide infection.

Collar-rot, as it is locally known, has been found in some of the orchards of the valley and many apple trees have been affected seriously. Methods of control of this disease are being studied.

The codling moth is perhaps the worst pest of the valley, but with thorough spraying at the correct periods it is believed that it may be controlled. The other insect pests of economic importance now known to be in the valley are San Jose scale, oyster-shell scale, Lecanium scale, woolly aphis, green aphis, and rosy-apple aphis.

Apple and pear scab are now found to a limited extent, but thus far have caused but little damage.

CLIMATE.

The climate of Yakima Valley is decidedly arid, and without irrigation the growing of agricultural crops would be impossible. The temperature during the summer often reaches 100° F., but because of the relatively low humidity it is not oppressive. The winters are generally mild with but light snowfall.

There was an annual average of 187.4 growing days at Yakima in the five years 1910–1914, inclusive. The Ahtanum Valley itself is well protected from severe winds; but in the lower valley, where the country is more open, winds often cause crop damage.

The mean annual precipitation for the five years 1910–1914, inclusive, at an altitude of 1,070 feet, North Yakima was 6.64 inches; in the Moxee Valley at an altitude of 1,000 feet it was 7.47 inches. For the 22 years 1893–1914, inclusive, the mean annual precipitation of the Moxee Valley was 8.36 inches. The greatest precipitation takes place in the months of November, December, and January, and the least occurs in the months of April, July, and August.

For the most part the climate of Yakima Valley may be said to be very pleasing and healthful.

TOPOGRAPHY.

Yakima County receives its water for irrigation purposes from the Yakima River and its tributaries. This river has its source on the eastern slope of the Cascade Mountains, taking an easterly and southeasterly course, entering the northern part of Yakima County and flowing into the Selah Valley, a plain about 4 miles in length. At the end of this valley it passes through a narrow gap into the upper Yakima Valley. From here it pursues its southerly course east of the city of North Yakima and about 6 miles south passes through what is known as Union Gap and enters its lower valley, in which are located Parker, Zillah, and Sunnyside. The upper valley is bounded on the north by Selah Ridge and Cowiche Ridge, and on the south by Yakima Ridge and Ahtanum Creek. The valley between the Yakima and Selah Ridges east of Yakima River is known as the Moxee Valley and that between Yakima and Cowiche Ridges west of Yakima River is known as the Ahtanum Valley. The total length of this valley is from 75 to 80 miles and the width is not greater than from 5 to 6 miles. The slopes of the

ridges of the valley are steep and rocky, but the valley itself is nearly level, with a gentle slope toward the Yakima River. (Pls. I, II, III, and IV.)

METHOD OF PRESENTATION.

In analyzing the cost of production in the Yakima Valley it is deemed advisable to give the results of the management under the two more common methods of handling the soil, namely, clean cultivation and the mulch-crop system. The former refers to orchards which are annually cultivated and in which no cover or mulch crop is sown. The latter refers to orchards in which the growing of alfalfa, clover, and vetch is the practice. Alfalfa is grown in practically all the mulch-crop orchards considered in this study. The method of management is fully discussed under the subject Mulch Crop.

The cost of production of apples in orchards under each method of management will be given separately for North Yakima and Zillah. These will then be combined to show a cost of production of each method of management for the valley, and finally the cost of production will be given in all orchards considered in this study regardless of the method of orchard management.

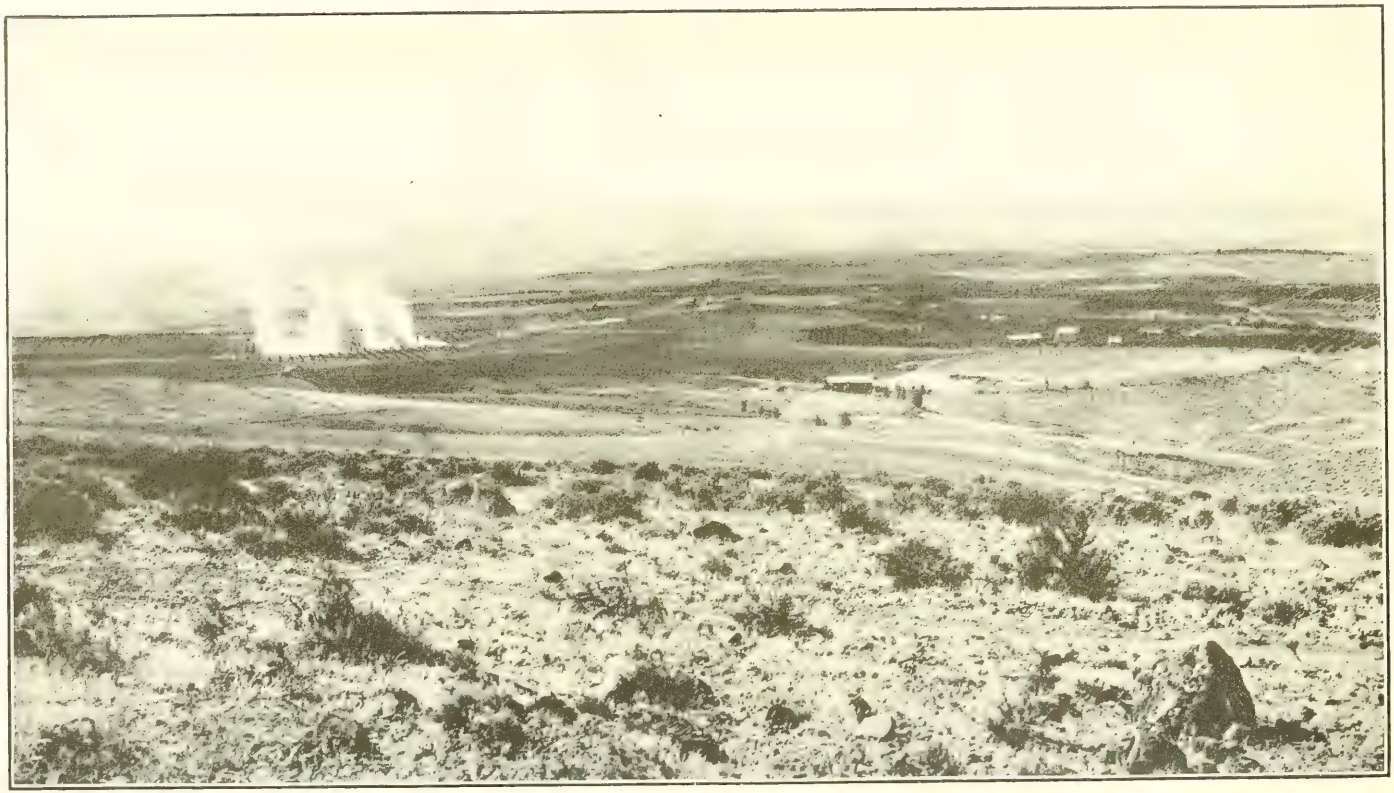
Four kinds of costs are considered in arriving at the total annual cost of production—(1) maintenance, (2) handling, (3) material, and (4) fixed, which are subdivided as follows:

Labor costs.		Costs other than labor.	
Maintenance.	Handling.	Material.	Fixed.
Manuring. Pruning. Disposal of brush. Cultivating. Irrigating. Thinning. Propping. Spraying. Miscellaneous. Sowing mulch crop. Harvesting mulch crop.	Hauling shooks. Hauling boxes to and from orchard. Picking. Packing-house labor. Hauling packed boxes. Picking up and hauling culls.	Manure. Spray material. Seed. Gasoline and oil. Made-up boxes.	Interest. Apple-building charge. Equipment charge. Sprayer hire. Taxes. Insurance. Water rent.

FARM ORGANIZATION.

The most intensive type of specialized agriculture of the entire valley is found in the vicinity of North Yakima. The apple is the most extensively grown fruit, although the pear, peach, plum, and some of the smaller fruits are common. The ranches are small, with usually a tract of commercial orchard. However, most ranchers produce enough garden truck for their own families. Many of the owners do much of their own work. Not all ranches are fully equipped with the necessary implements for orchard work, though the owners are generally able to exchange, borrow, or hire them at their

CLEARING LAND PREPARATORY TO SETTING TREES IN THE YAKIMA DISTRICT.



A VIEW OF THE OUTLYING FRUIT SECTION OF YAKIMA VALLEY. THIS IS AN EXTENSION OF THE "NOB HILL" SECTION.

VIEW OF THE LOWER NACHES VALLEY, ONE OF THE IMPORTANT FRUIT-GROWING VALLEYS TRIBUTARY TO THE YAKIMA DISTRICT.

The orchard in the foreground is one of apples and peaches interset.

STUMP LAND IN THE PROCESS OF BEING CLEARED.

Stump lands are found in the higher regions and upper valleys. They are much more expensive to clear than sagebrush lands.

convenience. Some keep but one horse, with which most of the light work may be done. For heavy work arrangements sometimes are made for the use of a neighbor's horse for short periods. The rancher usually keeps a cow, a few pigs, and a small flock of poultry. Where the orchards are under mulch-crop management there is a tendency to keep a somewhat greater number of such animals. Ranches in the Zillah district are comparatively large and more of an attempt is made at diversification than in the upper valley, where the orchards occupy a larger percentage of the farm acreage. Even so the type of farming remains highly specialized and fruit is the principal crop. Here is found a greater acreage of pears, cherries, and other fruits, and until recent years peaches were grown to a considerable extent. The Zillah ranches have a larger acreage in young fruit than those in the North Yakima district and more land is devoted to the growing of other crops, particularly alfalfa. The typical ranch is of such size that the operator devotes most of his time to the work on his own place. In this region there is a growing tendency to raise alfalfa in the orchards to be used for hog pasture.

SIZE OF RANCH.

The ranches of the North Yakima district are usually small. Of the 64 considered in this investigation, extreme acreages are 2 and 40. Most of the ranches range between 2 and 20 acres in size. The average ranch contains 10.79 acres, with 5.18 acres of apples in bearing. Nearly every ranch has a few pear, cherry, and plum trees and a small acreage of young apple trees. Nonbearing apples average 3.34 acres per ranch. On the average less than one-half acre is devoted to the growing of other crops. (See Table III.)

The apple orchard is usually of such size that one man can comfortably do all pruning and look after the necessary operations with but little extra help except during the thinning, spraying, and harvesting periods.

TABLE III.—*Average size of ranch and of areas in crops for 64 ranches in the North Yakima district.*

Item.	Method of culture.	
	Clean (43 records).	Mulch-crop (21 records).
Average acres in ranch	11.96	8.40
Average tillable acres in ranch	11.77	8.28
Average acreage in bearing apple orchard	5.49	4.52
Average acreage in young apples and other fruit	5.90	3.46
Average acreage in other crops	.38	.30
Tillable acres per horse	5.75	4.81

The 56 ranches in the Zillah district considered in this investigation are somewhat larger than those in North Yakima, ranging from 8 to 60 acres. The average size is 21.57 acres, with 7.77 acres in bearing

apples. There is an average per ranch of 6.28 acres in nonbearing apple orchard and 1.79 acres in other fruits. As already indicated, a greater acreage is devoted to other crops here than elsewhere in the district, there being an average of 4.17 acres of such crops per farm, 3.23 acres of which are in alfalfa. On account of the size of farm perhaps the rancher is not able to put in as much time on the bearing apple orchard as is the usual case in the North Yakima district. (See Table IV.)

TABLE IV.—*Average size of ranch and of areas in crops for 56 ranches in the Zillah district.*

Item.	Method of culture.	
	Clean (32 records).	Mulch-crop (24 records).
Average acres in ranch	22.26	20.66
Average tillable acres in ranch	21.56	19.98
Average acreage in bearing apple orchard	7.70	7.85
Average acreage in young apples and other fruit	9.33	6.40
Average acreage in other crops, including pasture	4.53	5.73
Tillable acres per horse	8.04	7.92

TYPES OF RANCHERS.

Two distinct types of ranchers are found in the valley. In the North Yakima district are found men engaged in ranching who were formerly professional men and tradesmen in different parts of the United States. Many of these men are at present interested in some other business besides ranching. The orchard is more or less incidental to the welfare of such men. However, there are several men who came to this section unacquainted with the business of apple growing, expecting soon to acquaint themselves with it and make a comfortable living and at the same time have all the privileges of the near-by city. Many of the owners of these small tracts are interested in the development of orchards farther away from town.

In the Zillah district are found ranchers of a somewhat different type. Many of these men were engaged in other lines of farming before coming to this region to settle. Some came at an early date, when the price of land was between $30 and $50 an acre, but there are many who came during the boom period and paid high prices for their land. A number of the ranchers were eastern and central-western farmers. This type of rancher as a rule is acquainted with general farming and usually is found growing other crops than fruit and raising some stock besides.

The ranchers of both districts are generally well educated. Up-to-date schoolhouses are found in many parts of the valley. (See fig. 2.) A few men in the Zillah district own property farther down the lower valley and devote it somewhat to hay growing and cattle raising, but this is not the general rule.

INVESTMENT.

The average investment per ranch of the 120 ranches studied in the Yakima Valley was $14,504.32, or $1,235.70 per acre. The areas in proximity to North Yakima have the advantages of the city. In the Nob Hill section, nearness to North Yakima, beautiful location, and the numerous incidental advantages of such an ideal situation make this acreage almost a prohibitive investment to one who must depend solely upon the income from the apple business, for at the time of this investigation merely the interest on such an investment amounted to a large proportion of the total annual cost of apple production. However, many men with independent incomes, wishing to establish beautiful homes under ideal conditions, bought small tracts of orchard and

FIG. 2.—A community district school in the Tieton district, many miles from railroad. Such schools are a product of progressive ranches and progressive ideas. They are a measure of rural social conditions of the region.

retired from active business life, expecting that the apple business would give them fair incomes. Many did not then consider the interest on their investment. Furthermore, prices then received for apples were high and in many instances seemed to warrant the prices asked for land.

As far as location and climate are concerned, it would be difficult to find in the Northwest apple-producing areas a region surpassing Yakima Valley.

Considering separately the 64 ranches in the North Yakima district, the average investment per ranch of 10.79 acres is $15,639.29, of which $7,525.78 is the estimated value of the bearing apple orchard per ranch. This estimated value of the average apple orchard is

52.57 per cent of the total investment. A greater valuation per acre was reported for ranches on which orchards are under mulch-crop than for those under clean-culture management. This is due primarily to location, land values being as a rule higher in the Nob Hill section, where more of the orchards are in a mulch crop, than in the Fruitvale or Broadway localities, where clean cultivation is practiced by nearly all orchardists from whom data were obtained. (See Table V.)

TABLE V.—*Average size of ranch and bearing orchard and average investment per ranch and per acre for 64 ranches in North Yakima district.*

Item.	Method of culture.		
	Clean.	Mulch-crop.	Combined.
Number of records	43	21	64
Average acreage per ranch:			
Total	11.96	8.40	10.79
In bearing apple orchard	5.49	4.52	5.18
Average investment per ranch:			
Total	$16,329.71	$14,225.57	$15,639.29
Land and improvement	$15,695.12	$13,532.00	$14,985.34
In bearing apple orchard	$7,708.14	$7,152.38	$7,525.78
Equipment	$335.88	$357.48	$342.97
Average investment per acre apple orchard:			
Total	$1,469.77	$1,657.14	$1,531.25
Equipment	$33.11	$39.12	$35.08
Per cent value apple orchard is of total investment per ranch [1]	51.00	55.79	52.57

[1] Average of percentage figures for the individual ranches.

The Zillah district presents a somewhat different aspect. It is located in the lower valley, which is not quite as highly specialized an apple-producing area as the North Yakima district. The ranches are larger, and, although more diversified, the raising of the apple is the chief ranch enterprise. The homes of the ranchers here are not so pretentious as those of the Nob Hill section, but the people enjoy all the advantages of an up-to-date rural community and have good train service to the city of North Yakima.

For the 56 ranches studied in the Zillah district the average investment per ranch of 21.57 acres is $13,207.21, of which $4,409.20 is the estimated value of 7.77 acres of bearing apple orchard per ranch. The value of the bearing apple orchard is 37.23 per cent of the total investment. (See Table VI.)

These investments are high in comparison with many of the farms in the Eastern apple-producing regions, but they are not exorbitant as compared with those of other Western and Northwestern apple-producing regions. (See Table VII.)

TABLE VI.—*Average size of ranch and bearing orchard and average investment per ranch and per acre for 56 ranches in Zillah district.*

Item.	Method of culture.		
	Clean.	Mulch-crop	Combined.
Number of records	32	24	56
Average acreage per ranch:			
Total	22.26	20.66	21.57
In bearing apple orchard	7.70	7.85	7.77
Average investment per ranch:			
Total	$13,487.83	$12,833.06	$13,207.21
Land and improvement	12,334.06	11,787.29	12,099.73
In bearing apple orchard	4,338.75	4,503.13	4,409.20
Equipment	486.25	464.46	476.91
Average investment per acre apple orchard:			
Total	564.38	562.50	563.57
Equipment	25.62	26.62	26.09
Per cent value apple orchard is of total investment per ranch [1]	35.42	39.64	37.23

[1] Average of percentage figures for the individual ranches.

The interest on the apple-orchard investment in these districts is very high, averaging 24.98 per cent of the total annual net cost of production on the 120 farms studied.

The investment in equipment is heavy, totaling $342.97 per ranch, or $35.08 per acre, in the North Yakima district; $476.91 per ranch, or $26.09 per acre, in the Zillah district; and $405.48 per ranch, or $30.88 per acre, for the 120 ranches studied.

The equipment investment usually includes all necessary equipment for orchard work, such as spray outfit, spring and spike tooth harrows, plows, cultivators, wagons, pruning tools, ladders, and miscellaneous orchard tools.

The average investment per ranch for the 120 considered in this study was $14,504.32, of which $6,071.38 was in bearing apple orchards. (Ranches averaged 15.82 acres and orchards 6.39 acres.) This apple-orchard investment is 45.41 per cent of the total investment.

TABLE VII.—*Comparative investments of four commercial apple-producing regions.*

Item.	Yakima Valley.	Hood River Valley.	Wenatchee Valley.	Western Colorado.
Average investment per ranch	$14,504.32	$23,487.36	$20,974.00	$16,366.87
Average land and improvement investment per ranch	$13,638.73	$22,503.70	$20,097.00	$15,340.14
Investment in bearing apple orchard per ranch	$6,071.38	$12,257.87	$12,250.00	$6,657.34
Investment in bearing apple orchard per acre	$1,079.67	$990.74	$1,925.00	$653.49
Equipment investment per ranch	$405.48	$491.87	$444.00	$708.51
Equipment investment of bearing apple orchard per acre	$30.88	$22.67	$44.65	$29.56
Per cent value of total ranch investment the bearing orchard represents	45.41	54.03	58.00	40.70
Average acres per ranch	15.82	39.49	11.40	38.24
Average acres in bearing apples per ranch	6.39	12.45	6.50	10.81

ORCHARDS.

SIZE.

The largest orchard considered in the North Yakima district was 20 acres, the smallest 1 acre. The orchards from which records were obtained under mulch-crop management averaged 4.52 acres, a little smaller than the clean-cultivated, which average 5.49 acres. The bearing apple orchard occupies about the same proportion of the ranch under either system of management. There is an average of 5.18 acres of bearing apple orchard out of 10.79 acres per ranch on the farms studied in the North Yakima district.

In the Zillah district the orchards under mulch-crop management average 7.85 acres, and clean-cultivated orchards average 7.70 acres. The bearing apple orchard occupies about the same proportion of the ranch under either method of management. Considering all bearing orchards in the Zillah district, regardless of the method of soil management, the average size is 7.77 acres out of an average of 21.57 acres per ranch.

The average bearing apple orchard of the valley, when all records are considered, is 6.39 acres out of the average of 15.82 acres per ranch.

AGE.

The average age of all orchards considered in this investigation was 12.6 years. The clean-culture orchards average 12.73 years and the mulch-crop orchards average 12.37. The average age of orchards in the Zillah district was 12.54 years, while in the Yakima district the average was 12.66. Trees in these districts, as in other Northwestern apple-producing sections, may be considered as bearing at 7 years of age, and only orchards this old or older were considered in this investigation. Practically all varieties will bear on an average a box or more of marketable apples per year between the ages of 6 and 9. There were not yet in bearing 1,827 acres, or 58.24 per cent of the total apple acreage in the Zillah district; in the Nob Hill area there were 2,501 acres, or 62.89 per cent. The age of bearing orchards in the Zillah district varies from 8 to 22 years, though generally there seem to be two groups, those 8 to 12 years and those 18 to 22 years. The younger orchards appear to be the best cared for and the most profitable.

VARIETIES.

Between 50 and 60 varieties are grown by the orchardists from whom records were taken. The older orchards of the valley contain such varieties as Monmouth, York Imperial, Twenty Ounce, Missouri, and Ben Davis. As in other Northwest regions, earlier plantings were made of varieties well known to the ranchers in their home States. The small family orchards were the beginning of the

industry and contained many of the above mentioned varieties. With the development of the industry came the knowledge of the varieties better adapted to the region.

The principal commercial varieties now grown in Yakima County are Winesap, Jonathan, Ben Davis, Esopus, Missouri, etc. (See Table VIII.)

TABLE VIII.—*Ten varieties of apples having the largest acreage in Yakima County.*

Variety.	Acres.	Per cent of total acreage.
Winesap	6,201	15.52
Jonathan	5,916	14.81
Ben Davis	5,103	12.77
Esopus (Spitzenberg)	2,654	6.64
Missouri	2,578	6.45
Yellow Newtown	2,366	5.92
Rome Beauty	2,203	5.51
Gano	1,339	3.40
Arkansas (Black Twig)	1,075	2.69
Stayman Winesap	991	2.48

METHOD OF ORCHARD PLANTING.

Many of the older orchards of the valley are set as close as 15 by 15 or 20 by 20 on the square. However, in many instances the orchardists are removing part of the trees so as to get sufficient space for the growth and development of those remaining. Among the younger orchards the distances set vary from 20 by 20 to 30 by 30, trees being set on different plans. As might be expected, there is little difference in the plan of setting between the clean-cultivated and the mulch-crop orchards, since most of these orchards were set before any consideration was taken of an orchard mulch crop. Considering all orchards in the Zillah district, regardless of the plan of setting, there was an average of 68.2 trees per acre. In the North Yakima district there was an average of 78.2 trees per acre. Considering all records taken in the valley, there was an average of 73.6 trees per acre.

YIELDS.

Records of yields were obtained from each orchardist covering as long a period as possible. (See Table IX.) The plan was to get records covering at least a 5-year period, so that any abnormality in one year or another might be minimized in the average. The belief was that fair results could not be counted on from the consideration of any one year's yield, since many conditions, such as the weather, insect pests, and fungus diseases, often make the yield for a given season entirely unreliable as a measure of the business of a district. In 1911 a severe frost affected the yield of many of the orchards of the valley. Two ranchers considered in this investigation lost their entire crops that year.

TABLE IX.—*Average yield per acre, 1910–1914, inclusive, for 120 orchards in Yakima Valley.*

Year.	North Yakima district.		Zillah district.		North Yakima and Zillah districts combined.	
	Number of records.	Average yield in packed boxes.	Number of records.	Average yield in packed boxes.	Number of records.	Average yield in packed boxes.
1910	20	617.1	24	464.7	44	534.0
1911	30	277.9	33	216.8	63	246.0
1912	51	617.3	48	591.3	99	604.7
1913	62	354.6	54	328.6	116	342.5
1914	64	590.5	56	452.3	120	526.0

There is a difference in the number of estimates considered in different years, yet the figures presented reflect the tendency to alternate bearing, as well as the effects of weather conditions.

The age of the trees has a marked bearing on the yield for these districts. Some varieties of apples in the Yakima Valley bear a few apples at the age of 5 years. However, in arriving at the average yield for the valley only the yields from orchards aged 7 years and over are considered. The majority of orchards from which records were taken were between the ages of 9 and 15 years at the time of this study. Each orchard is given the same weight and the acre is used as a basis of comparison. All yields were taken from orchards representitive of the district, so as to make the data comparable. There is a gradual increase in the yields of trees from the time they are 6 years of age. (See Table X.)

It will be noted that the yield per tree increases rapidly with the age until the tree reaches 9 years of age and that thenceforward the increase is more gradual.

There were not enough records of orchards over 12 years of age to furnish reliable figures.

TABLE X.—*Yield per acre from trees of different ages in the Yakima Valley.*

Number of estimates.	Age of trees.	Yield in packed boxes.	Trees per acre.	Boxes per tree.
42	6	175	75.66	2.32
58	7	311	73.50	4.23
73	8	350	73.82	4.74
70	9	453	73.71	6.14
56	10	454	74.32	6.10
51	11	469	72.12	6.51
33	12	505	73.97	6.83
Average from total			73.81	

The size of the orchard appears to have considerable influence on the yield throughout the districts. (See Table XI.) Small orchards have more trees per acre than the larger ones, and as a rule the ranch

is proportionately small. The trees in the small orchard usually get more care and individual attention than those in the big orchard.

The average yield of the orchards studied is here presented regardless of the size of orchard, variety of apple, and the age of the trees, 7 years and over, without consideration of the year.

The average yield per acre in the North Yakima district in orchards under clean-culture management was 475 packed boxes, or 6 packed boxes per tree. In the orchards considered 79 trees per acre was the average. The average yield per acre in orchards under the same method of management in the Zillah district, with an average of 69 trees per acre, was 421 packed boxes, or 6.1 boxes per tree.

The average yield per acre in the orchards of the North Yakima district under mulch-crop management was 434 packed boxes per acre, or 5.7 boxes per tree. These orchards averaged 76 trees per acre. The average yield per acre in the Zillah district for orchards under the same system of management was 367 packed boxes, or 5.5 boxes per tree. These orchards averaged 67 trees per acre.

TABLE XI.— *Yields of 120 orchards of varying acreages and different cultural methods in Yakima Valley.*

Acres in orchard.	Clean-cultural management.					Mulch-crop management.				
	Number of records.	Average age.	Packed boxes per acre.	Trees per acre.	Boxes per tree.	Number of records.	Average age.	Packed boxes per acre.	Trees per acre.	Boxes per tree.
1 to 5	44	12.8	496.8	77.3	6.43	22	12.5	435.2	73.8	5.90
6 to 10	19	12.9	414.3	74.2	5.58	19	12	375	66.6	5.63
11 to 20	12	12.3	348.3	67.1	5.19	4	13.8	304.2	80.4	3.78
Total	75	12.7	452.2	74.9	6.04	45	12.4	398.1	71.3	5.58

Acres in orchard.	Combined management.				
	Number of records.	Average age.	Packed boxes per acre.	Trees per acre.	Boxes per tree.
1 to 5	66	12.7	476.3	76.2	6.25
6 to 10	38	12.5	394.7	70.4	5.61
11 to 20	16	12.7	337.3	70.3	4.80
Total	120	12.6	431.9	73.6	5.86

The orchards under clean cultivation show a slightly larger yield than those under mulch-crop management. The difference is not large, however, when considered on a comparable basis. There is an average yield of 0.3 box more per tree under clean-cultural than under mulch-crop management in the Yakima district and 0.6 box more per tree in the Zillah district. Assuming that there are the same number of trees per acre—for example, 70—there would be

an average yield of only 21 boxes more per acre under clean-cultural than under mulch-crop management in the Yakima district, while in the Zillah district there would be an average yield of 42.1 boxes more per acre under clean-cultural management.

A few years ago all men in the valley practiced clean cultivation. Of late years many of the orchards have been sown to alfalfa or clover. (See fig. 3.) In many cases the orchards which were clean cultivated showed the effect of too intensive cultivation and the need of humus. There seems to be a tendency on the part of some growers, after orchards have been sown to a mulch crop, to neglect the orchard in different ways. These seemingly small oversights have their effect on the physical condition of the trees, and thus

FIG. 3.—An 8-year old Esopus and Winesap orchard in the Zillah section. The Esopus trees are badly affected by blight. Note the dense mulch crop of alfalfa.

upon the yield. This is especially noticeable in the Zillah district, where men are using their mulch-crop orchards for pasturing hogs. On the whole, these orchards are not managed so carefully and thoroughly as those under clean cultivation. Great care must be taken with the Yakima Valley orchards in a mulch crop until the practice has been in vogue for a sufficient time to enable the growers to become familiar with the details and results of mulch-crop management. Not alone in the Northwest does there seem to be this tendency to neglect orchards in mulch crop, but in some of the larger commercial apple-producing sections of the East a similar tendency is apparent, especially when the price of apples does not seem to warrant scrupulous care.

Since the mulch crop has not been used generally in this district for any length of time, the true effects, as far as yields are concerned, do not seem yet to be in evidence. It is a recognized fact, however, that the orchards are in need of humus, and perhaps in many cases the mulch-crop system, with proper management, would bring good results. However, whatever the system of management, if the orchards are to be kept in good physical condition and are to bear the average crop or more, due care must be taken in the management.

Considering the valley as a whole, regardless of whether the orchards are under clean-cultural or mulch-crop management, there is an average yield of 432 packed boxes per acre, or 5.87 boxes per tree, the orchards ranging from 7 to 22 years of age and averaging 73.6 trees per acre.

ORCHARD MAINTENANCE.

Under orchard maintenance are included those practices which at the time of this study usually were followed by 120 orchardists of the Yakima Valley in the upkeep of their bearing apple orchards. Among these are manuring, pruning, disposal of brush, soil management, thinning, propping, spraying, and any miscellaneous labor previous to handling the crop.

MANURING.

Manuring is the annual practice of 77 per cent of all orchardists considered in this investigation. It is obvious from the small number of work horses and other stock on the average ranch that the amount of manure annually produced is small, yet few of the ranchers buy any manure in town or have it shipped in from other points. Most of the manure produced is usually applied on the bearing apple orchard, except for the small amount which is often used on the garden. Often, however, growers are found who make a practice of applying a considerable amount on the younger orchards. As a rule, there is not enough produced on the average ranch to manure the entire bearing apple orchard each year. (See Table XII.)

Eighty per cent of the ranchers visited in North Yakima and 73 per cent in Zillah made a practice of manuring all or a portion of their orchards each year. The former apply an average of 4.78 tons and the latter 7.72 tons per acre.

TABLE XII.—*Average time, tons, and cost per acre when a crew of one man and two horses is used for manuring orchards in Yakima Valley.*

District.	Number of records.	Hours.		Acres in 10 hours.	Labor cost.	Tons.	Material cost.	Total cost.
		Man.	Horse.					
Under clean-cultural management:								
North Yakima	25	8.51	17.02	1.17	$4.68	5.52	$8.28	$12.96
Zillah	21	10.88	21.76	.92	5.99	8.50	12.75	18.74
North Yakima and Zillah	46	9.59	19.18	1.04	5.28	6.88	10.32	15.60
Under mulch-crop management:								
North Yakima	14	7.49	14.98	1.34	4.12	4.14	6.21	10.34
Zillah	14	9.05	18.10	1.10	4.98	5.62	8.43	13.41
North Yakima and Zillah	28	8.27	16.54	1.21	4.55	4.88	7.32	11.87

Considering the orchardists in the North Yakima district who actually apply manure, regardless of method or crew used, it requires 7.70 man hours and 13.93 horse hours to apply 4.78 tons per acre, at a cost of $11.20 for both material and labor, while in the Zillah district it requires 12.06 man hours and 20.73 horse hours to apply 7.72 tons per acre at a cost of $17.71 for both material and labor. Considering only those orchardists in both districts who actually manure, it requires 9.65 man hours and 16.96 horse hours to apply 6.09 tons per acre at a cost of $14.10 for material and labor. Seventy-six per cent of all orchardists under mulch-crop management and 77 per cent under clean-cultural management manure each year. However, considering the small amount of manure produced on the average ranch and the small acreage covered each year, much more was actually applied on the latter than on the former, the latter applying 6.74 tons and the former 4.99 tons per acre.

Different methods are used in applying manure, some men using a sled and others a wagon for hauling purposes. Manure is applied during the fall and winter months, usually being spread from the sled or wagon as the hauling is done. A few, however, put it in piles and spread it at their convenience. If there are certain trees which seem to need manure more than others, it is applied to these trees rather than spread uniformly throughout the orchard. Eighty per cent of the orchardists manuring each year use a one-man and two-horse crew, and 12 per cent use a one-man and one-horse crew. The remainder use a crew of two men and two horses.

TABLE XIII.—*Number of hours and cost per acre required for manuring in orchards in Yakima Valley.*

District.	Number of records.	Hours.		Labor cost.	Tons per acre.	Material cost.	Total cost.
		Man.	Horse.				
Under clean cultural-management:							
North Yakima	43	6.05	11.00	$3.16	4.02	$6.03	$9.19
Zillah	32	10.14	17.29	5.13	6.81	10.21	15.34
North Yakima and Zillah	75	7.80	13.68	4.00	5.21	7.82	11.82
Under mulch-crop management:							
North Yakima	21	6.32	11.31	3.28	3.38	5.07	8.35
Zillah	24	7.09	12.37	3.63	4.11	6.17	9.80
North Yakima and Zillah	45	6.73	11.88	3.46	3.77	5.66	9.12
All orchards:							
North Yakima	64	6.14	11.10	3.20	3.81	5.72	8.92
Zillah	56	8.83	15.18	4.48	5.65	8.48	12.96
North Yakima and Zillah	120	7.40	13.00	3.80	4.67	7.01	10.81

Table XIII shows that more manure is applied per acre in the Zillah than in the North Yakima district, also that 2 tons more are applied per acre on orchards under clean-cultural management than those under mulch-crop management. There is little difference in the time consumed in applying manure under the different conditions.

Regardless of the orchard management, a crew of one man and two horses will cover 1.10 acres in 10 hours, applying 6.12 tons per acre at a cost of $14.19 for labor and material.

Considering all records, regardless of method of applying or crew used, there is a charge of 7.40 man-hours and 13.00 horse-hours per acre or a labor cost of $3.80 and material cost for 4.67 tons of $7.01, making a total manure cost of $10.81 per acre.

PRUNING.

Pruning is an annual practice of all orchardists throughout the valley. It is usually done during the winter and early spring, when the trees are still dormant. The ranchers, members of their families, or the regular hired help do most of the pruning, but a few have this work done by contract labor.

The majority of growers prune heavily every year. Some do the heavy pruning in the years when a big crop is expected, lessening to a great extent the amount of labor and cost necessary for thinning and propping. However, the practice of heavy pruning preceding a large crop does not hold true in all instances. Pruning is really another method of thinning, although even with careful pruning it is usually necessary to do a certain amount of thinning. The amount of pruning also has a bearing on the health and vigor of the individual tree. Very few orchardists make a practice of summer pruning.

TABLE XIV.—*Cost of pruning in orchards in Yakima Valley.*

District.	Number of records.	Average number of acres in orchard.	Trees per acre.	Average age.	Trees pruned in 10 hours.	Man-hours per acre.	Cost.		
							Per acre.	Per tree.	Per box.
Under clean-cultural management:									
North Yakima	43	5.49	79.21	12.58	14.10	56.16	$14.04	$0.177	$0.0296
Zillah	32	7.70	69.07	12.94	13.72	50.36	12.59	.182	.0299
North Yakima and Zillah	75	6.44	74.88	12.73	13.95	53.69	13.42	.179	.0297
Under mulch-crop management:									
North Yakima	21	4.52	76.26	12.31	14.03	54.38	13.60	.178	.0313
Zillah	24	7.85	67.03	12.00	14.14	47.39	11.85	.177	.0323
North Yakima and Zillah	45	6.30	71.33	12.37	14.08	50.65	12.66	.178	.0318
All orchards:									
North Yakima	64	5.18	78.24	12.66	14.10	55.58	13.90	.179	.0301
Zillah	56	7.77	68.19	12.54	13.50	49.08	12.27	.179	.0308
North Yakima and Zillah	120	6.39	73.55	12.60	14.00	52.55	13.14	.179	.0304

On account of the closeness of setting and the rapid growth of the trees, it is necessary that this operation be done every year in order to keep the trees within reasonable control. There appears to have been no definite plan of shaping the trees which were planted earlier in the valley, but in the younger orchards the style of pruning is

toward a vase shape with open head. In the better cared-for orchards three to five leaders usually were chosen and headed back for the first 3 to 5 years, after which the pruning may be said to have consisted of merely the thinning out of the heavier lateral growth along the main limbs each year. When these trees reach the age of 12 years they usually are severely headed back, and from then on are pruned in such a manner as to prevent them from reaching a size or shape which will inconvenience the operator in doing the principal orchard operations. In the older orchards comparatively little heavy wood is cut from the trees.

Many factors affect the time required for this operation, chief among them being the variety, size, age, and number of trees per acre, as well as the expertness of the pruner. Perhaps the greatest of these factors is the pruner himself. His skill and ideals are told by each tree throughout the orchard. In considering these data no detailed study was made of the influence of these factors, the object being merely to obtain the average time required for the operation.

There appears to be little difference in the cost of this operation in the two districts. (See Table XIV). The majority of farms and orchards do not vary greatly in size, so that the time required for the pruning is not affected greatly by the size factor. However, where the ranches are small a larger percentage of the acreage is in bearing apples and usually there is a greater number of trees per acre. In the Nob Hill section this is especially true, for the orchards occupy such a large percentage of the total acreages and there is usually so little other work to be done that the men spend more time on this operation than do the farmers of the Zillah district, because they do not feel the pressure of other work.

Apparently there is little difference in the cost of pruning the trees under clean-cultural management as compared with those under mulch-crop management. There is, however, considerable variation in the number of trees which some men give as the average number which they are able to prune per day, the extremes being 6 and 60. Considering the valley as a whole, it is found that a man will prune an average of 14 trees 12.6 years of age in a 10-hour day.

The acre cost for pruning in the North Yakima district is $13.90; in the Zillah district it is $12.27. Considering the valley as a whole, the pruning cost is 19.5 per cent of the gross labor cost up to harvesting time. The tree cost for this operation (18 cents) is the same in both districts. The difference in the acre cost is due to the fact that there are 78.2 trees per acre in Yakima and but 68.2 in Zillah. Taking the valley as a whole, with an average of 73.55 trees per acre having an average of 12.6 years, 52.55 man-hours are required to prune an acre, at a cost of $13.14, or 18 cents per tree.

DISPOSAL OF BRUSH.

Several rather widely varying methods of brush disposal are employed, hence there is considerable range in the cost of this operation. A normal time could not be expected where there is such a wide variation in controlling factors. The regularity of pruning, the amount and kind of wood removed, as well as the method of handling and disposing of the brush, each has a considerable bearing on the time required for this operation. The cost of disposing of brush is nearly proportionate to the cost of pruning.

TABLE XV.—*Annual cost of disposing of brush in orchards in Yakima Valley.*

District.	Number of records.	Acres in orchard.	Hours.		Cost.		
			Man.	Horse.	Per acre.	Per tree.	Per box.
Under clean-cultural management:							
North Yakima	43	5.49	10.54	12.50	$4.51	$0.057	$0.0095
Zillah	32	7.70	12.21	10.98	4.70	.068	.0112
North Yakima and Zillah	75	6.44	11.25	11.85	4.59	.061	.0102
Under mulch-crop management:							
North Yakima	21	4.52	10.46	11.26	4.30	.056	.0099
Zillah	24	7.85	12.98	9.88	4.73	.071	.0129
North Yakima and Zillah	45	6.30	11.81	10.53	4.53	.064	.0114
All orchards:							
North Yakima	64	5.18	10.51	12.09	4.44	.057	.0096
Zillah	56	7.77	12.54	10.51	4.71	.069	.0118
North Yakima and Zillah	120	6.39	11.46	11.35	4.57	.062	.0106

There is little difference in the cost in the orchards under clean-cultural as compared with those under mulch-crop management. Considering all the records taken the former cost per acre is $4.59 and the latter $4.53. (See Table XV.)

The two more common methods used in disposing of the brush are:

1. A crew of either one man and one horse or two men and team with a wagon or sled is used to pick up, haul, and burn the brush left by the pruner.

2. The brush is often placed in piles. A crew, varying in size as stated above, pick up the brush either by hand or with forks, haul, and burn it.

In some instances a horse rake is used to clean up and carry the brush to a burning-place. However, two-man and two-horse crews are most commonly used in brush disposal in both the upper and the lower valley.

It is a general practice in some orchards where large limbs are removed to have the same trimmed up and used for fire wood. Where such a practice is usual, the time required for trimming up, together with the hauling of the wood to the ranch house, is considered and a credit to the orchard is made for the same.

There is little difference between the cost of removing brush in the North Yakima and in the Zillah districts. Considering all records

regardless of the crew used, there is an annual charge for removing brush of 11.46 man-hours and 11.35 horse-hours, or an acre cost of $4.57.

SOIL MANAGEMENT.

Not many years ago the orchardists of the irrigated regions were warned not to allow any vegetation to occupy the land between their trees, lest the trees be robbed of food and moisture. It was soon learned, however, that many of the soils of the arid and semiarid regions were well supplied with mineral matter, but lacked one element essential to the healthful and profitable development and maintenance of tree growth, namely, nitrogen. This lack, often made obvious by the condition of the trees themselves, forced many of the orchardists of the Northwest to resort to the use of such legumes as alfalfa, clover, and vetch to supply the missing element.

It now appears that the Northwest orchardists have done much in solving the problem of the high cost of soil management by the introduction of these crops. Though the use of legumes is a comparatively recent innovation, nevertheless the method of management of orchards under mulch crop now in vogue in the valley will be considered in this bulletin. The majority of orchards considered under this heading have used some legume as a mulch crop for the past 3 to 5 years.

CLEAN CULTIVATION.

The importance of cultivation in the cost of maintenance in orchards under clean-tillage methods is shown by the fact that when all orchardists using this system are considered the annual cultivation charge per acre is $11.26, or 15.92 per cent of the total gross labor cost up to harvesting time. The soil of the valley is such that many men do not find it necessary to use the plow for breaking the land, but depend principally upon the disk.

Table XVI shows the frequency with which different implements are used by orchardists in the Yakima district who practice clean cultivation. Table XIX gives the same for the Zillah district.

TABLE XVI.—*Implements and the number of orchards in which each is used in 43 orchards under clean-cultural management in the Yakima district.*

When used.	Plow.	Disk harrow	Spring-tooth harrow.	Spike-tooth harrow.	6-foot cultivator.	Cultivator.	Float.	Crease.
Before first irrigation	29	12	22	29	26	7	8	43
Following first irrigation	.....	2	15	14	24	6	2	43
Following second irrigation	.....	.....	13	10	26	5	2	41
Following third irrigation	.....	.....	10	7	19	4	.....	32
Following fourth irrigation	.....	.....	4	.....	7	2	.....	11
Following fifth irrigation	.....	.....	.....	.....	1	.....	.....	.....

It is the prime object of each orchardist following this method of management so to till the soil that a deep mulch which will conserve the moisture is present throughout the growing season. (See fig. 4.)

The soil is such that many orchardists do not feel the necessity of plowing annually. It is the practice, however, to begin some cultivation as early as possible in the spring, so as to conserve the moisture from the rain and snow of the winter.

The soil, broken by the various implements previously mentioned, is usually well worked, so that a dust mulch is formed. All growers make a practice of working the orchard both ways, many times practicing what is known as "zigzagging" in order to cultivate close up to the trees.

The importance of these early cultivations is shown by the fact that more than 40 per cent of the total cultivation, exclusive of plowing, is

FIG. 4.—Type of cultivator commonly used in Yakima Valley orchards.

made before the first irrigation. After the soil is once put in good condition comparatively little labor ordinarily will be required to keep it in condition to prevent the loss of moisture. Table XVII gives the average day's work with various cultural implements used by the orchardists of the valley.

The soil in most of the apple orchards in Yakima Valley considered in this investigation is a sandy loam, friable and easy to work. Both climatic and soil conditions are such that cultivations may be commenced as early as the middle of March. The majority of the orchardists begin the work on the soil before the middle of April.

Forty-three of the 64 orchardists visited in the North Yakima district practiced clean cultivation. Twenty-nine, or 67.44 per cent of this number, made a practice of doing some plowing. Fifteen

plowed every year, 8 every other year, 5 every three years, and 1 every four years. Of the 43 who practiced clean cultivation, the usual practice of 15 was to begin the annual cultivation with the plow, 7 with the disk harrow, 11 with the spring-tooth harrow, 4 with the spike-tooth harrow, 4 with a cultivator, and 2 with miscellaneous implements. Of the 15 who plowed annually, 13 plowed in the spring and 2 in the fall.

FIG. 5.—Cultivating by means of the spring-tooth harrow on one of the larger valley ranches.

TABLE XVII.—*Average time and cost per acre for various cultural operations in 75 orchards under clean-cultural management in Yakima Valley.*

Implement.	Crew.		Acres in 10 hours.	Cost per acre.
	Man.	Horse.		
Plow	1	2	1.58	$3.487
Disk harrow	1	2	5.18	1.062
Spring-tooth harrow	1	2	7.30	.754
Spike-tooth harrow	1	2	9.26	.594
6-foot cultivator	1	2	7.75	.710
Float	1	2	8.55	.644

The making of the deep dust mulch not only aids in the conservation of moisture but makes it possible for irrigation water readily to pass through the soil. As soon as the soil becomes packed and cracks open from improper care, irrigation water will not be taken up so readily. As soon as soil conditions permit, cultivations are made after each irrigation, usually until the middle of the summer or until the weight of the fruit bears the limbs down so as to interfere with

cultivation. Following this first series of cultivations and before the first irrigation, furrows are made with a cultivator or shovel plow for distributing the water throughout the orchard.

Referring to Table XVIII it will be seen that the most intensive cultivation is done just before and following the earlier irrigations. There is an annual charge of 24.26 man-hours and 41.28 horse-hours, or a cost of $12.26, per acre for cultivation in orchards under clean-cultural management in the Yakima district.

Fifteen, or 46.88 per cent of the orchardists in the Zillah district used the plow for cultural purposes. (See Table XX). Of the 32 orchardists in the Zillah district who followed the clean-cultural practice 10, or 31.25 per cent, began the annual cultivation with the plow, 21 with the disk harrow, and 1 with the spring-tooth harrow. Of the 10 orchardists who plowed each year, 9 plowed in the spring and 1 in the fall. Spring plowing seems to be preferred by orchardists in both the North Yakima and Zillah districts.

TABLE XVIII.—*Percentage of orchardists making cultivations and the time chargeable per acre in 43 orchards under clean-cultural management in the North Yakima district.*

Operation.	Per cent of orchardists making various cultivations.	Hours per acre.		Per cent of total cultivation.
		Man.	Horse.	
Plowing	67.44	3.07	5.71	
Cultivation:				
Before first irrigation	100	7.86	13.76	41.07
Following first irrigation	100	4.18	7.25	21.84
Following second irrigation	97.67	3.63	6.38	18.97
Following third irrigation	76.74	2.51	4.31	13.11
Following fourth irrigation	30.23	.91	1.65	4.75
Following fifth irrigation	2.33	.05	.10	.26
Total		19.14	33.45	100.00
Furrowing:				
Before first irrigation		1.31	1.98	
Before second irrigation		1.31	1.98	
Before third irrigation		1.24	1.89	
Before fourth irrigation		.93	1.47	
Before fifth irrigation		.33	.51	
Before sixth irrigation		.00	.00	
Total		5.12	7.83	

TABLE XIX.—*Implements and the number of orchards in which each is used in 32 orchards under clean-cultural management in the Zillah district.*

When used.	Plow.	Disk harrow.	Spring-tooth harrow.	Spike-tooth harrow.	6-foot cultivator.	Cultivator.	Float.	Crease.
Before first irrigation	15	24	16	15		2	4	[1] 31
Following first irrigation		7	19	8	2	3		31
Following second irrigation		4	19	5	2	3	1	27
Following third irrigation		3	9	3	1		1	13
Following fourth irrigation			1				1	1
Following fifth irrigation		1						

[1] One orchardist does not irrigate, therefore no creasing is made.

In Yakima many of the ranches are small and growers do not feel the necessity of having a variety of implements, but in the Zillah district the average ranch is larger, and many times other crops are grown, so that the individual growers usually have several different kinds of implements. The spring-tooth and disk harrows are by far the most common implement used for cultural purposes in the lower valley. (See fig. 5.)

Referring to Table XX, it will be noted that 97 per cent of the orchardists make a practice of cultivating after the first irrigation, 88 per cent following the second, and 44 per cent following the third. The orchardists in the Yakima district not only practice more intensive cultivation early in the season but continue it later in the season than do the orchardists in the Zillah region. Considering all the orchards which are clean cultivated in the Zillah district, there is an annual charge of 18.67 man-hours and 35.01 horse-hours, at a cost of $9.92 per acre.

That the size of the orchard and farm have some bearing on the amount of cultivation done is shown by Tables XXI and XXII.

TABLE XX.—*Percentage of orchardists making cultivations and the time chargeable per acre in 32 orchards under clean-cultural management in the Zillah district.*

Operation.	Per cent of orchardists making various cultivations.	Hours per acre.		Per cent of total cultivation.
		Man.	Horse.	
Plowing	46.88	2.45	4.89	.....
Cultivation:				
Before first irrigation	100	6.78	13.50	47.31
Following first irrigation	96.88	3.46	6.91	24.14
Following second irrigation	87.50	2.52	5.05	17.59
Following third irrigation	43.75	1.35	2.69	9.42
Following fourth irrigation	3.13	.14	.28	.98
Following fifth irrigation	3.13	.08	.16	.56
Total	.....	14.33	28.59	100.00
Furrowing:				
Before first irrigation	.....	1.30	1.98	.....
Before second irrigation	.....	1.27	1.86	.....
Before third irrigation	.....	1.10	1.65	.....
Before fourth irrigation	.....	.58	.84	.....
Before fifth irrigation	.....	.09	.09	.....
Before sixth irrigation	.....	.....	.....	.....
Total	.....	4.34	6.42	.....

TABLE XXI.—*Total time and cost chargeable per acre for cultivation in 43 orchards of various sizes under clean-cultural management in the North Yakima district.*

Number of records.	Acres in orchard.	Per acre.			Average acres in ranch.
		Man-hours.	Horse-hours.	Cost.	
31	1–5	26.23	42.85	$12.99	10.25
8	6–10	18.73	37.46	10.30	15.19
4	11–20	20.08	36.73	10.53	18.75

TABLE XXII.—*Total time and cost chargeable per acre for cultivation in 32 orchards of various sizes under clean-cultural management in the Zillah district.*

Number of records.	Acres in orchard.	Per acre.			Average acres in ranch.
		Man-hours.	Horse-hours.	Cost.	
13	1–5	21.07	39.86	$11.25	16.77
11	6–10	17.36	31.97	9.14	20.89
8	11–20	16.59	31.34	8.85	33.06

The intensiveness of cultivation varies to a considerable extent in each of these districts, but the figures indicate that costs of cultivation per acre in each district are higher for the orchards between 1 and 5 acres in size than for the larger orchards. Of course there is not any set rule as to the amount of cultivation which shall be done, but the whole plan of orcharding on small ranches in the Northwest tends toward intensiveness, and hence to a high cost of maintenance. On account of the small number of records for the larger orchards and ranches, it was impossible to bring out this fact as forcibly as was desired. Nevertheless, it would seem from the data that the smaller ranches and orchards tend toward more intensive methods.

The annual cost of cultivation on orchards of from 1 to 5 acres on ranches which average 10.25 acres in North Yakima was $12.99, while in the Zillah district, with orchards averaging approximately the same and with ranches which average 16.77 acres, the cost of cultivation is $11.25, and over $2 per acre more than on orchards of 6 to 10 acres in size where the ranches contain between 4 and 5 acres more.

TABLE XXIII.—*Average man-hours and horse-hours and cost chargeable per acre for cultivation, exclusive of plowing, in orchards under clean-cultural management in the Yakima Valley.*

District.	Number of records.	Average number of acres in orchard.	Per acre.			Cost per box.
			Man-hours.	Horse-hours.	Cost.	
North Yakima	43	5.49	24.26	41.28	$12.26	$0.0258
Zillah	32	7.70	18.67	35.01	9.92	.0236
North Yakima and Zillah	75	6.44	21.88	38.60	11.26	.0249

There is a total charge of 27.33 man-hours and 46.99 horse-hours, or $13.88 per acre, for all cultivation, including plowing, in orchards under clean-cultural management in the North Yakima district, and of 21.12 man-hours and 39.90 horse-hours, or $11.27 per acre, in the Zillah district. Table XXIII gives the cost chargeable per acre for cultivation exclusive of plowing in orchards under clean cultivation.

Considering the valley as a whole, there is a charge of $12.76 per acre for all cultivation, including plowing, or a packed-box charge of $0.0282.

MULCH CROP.

The term "mulch crop" in this connection refers to the practice of growing alfalfa, clover, and vetch in the orchard for hay or pasture.

Of the 120 orchardists from whom records were taken in the Yakima Valley, 45, or 37½ per cent, had sown their orchards to one of these shade or mulch crops. Alfalfa, however, is used most commonly.

Two rather distinctive methods of handling the mulch crop are practiced in the orchards of the valley. Some men cut and use the mulch crops for hay; others utilize the orchards for pasture. Of the 64 orchards in the North Yakima district, 21 have some mulch crop in their orchards; 19 of these use the mulch crop for hay, and 2 use it for pasture. Of the 24 orchardists in the Zillah district who use a mulch crop, 14 use the mulch for hay, 9 for pasture, and 1 leaves it on the ground. As alfalfa is the principal mulch crop grown by orchardists from whom records were obtained, this discussion will be confined entirely to the methods commonly practiced in the management of the orchards which were in this mulch crop.

In both districts where alfalfa is used for hay, the practice is to do some cultural work in the orchards. This is not necessarily done every year. A few of the orchardists make an annual practice of thoroughly disking the alfalfa as early as possible in the spring. This cuts the crowns and causes the plants to spread, producing new growth. An annual cultivation in the mulch-crop orchards is not common in the valley, only four orchardists in each district following this plan. The others allow it to remain in the orchard from two to four years. The orchard is then plowed, worked, and reseeded. Mulch-crop management is practically the same for both districts. (See Tables XXIV and XXV.)

The annual cultivation charge per acre of all orchards in the valley under clean-cultural management is 15.92 per cent of the total gross labor cost up to harvesting time, whereas in orchards under mulch-crop management it is only 6.06 per cent. In order to find the annual charge per acre on the orchards where cultivations are made only once in two to four years, the labor put on these orchards during the year of cultivation is prorated over the years when no cultivation is made. For example, if an orchard is plowed and cultivated once in four years, the annual charge per acre for labor will be one-fourth of the total labor done during the year of cultivation. Where all records are considered, regardless of the method of management of the soil, approximately 80 per cent of the total annual cultivation is made in both districts before the first irrigation.

Considering all mulch-crop records in the valley, whatever method of management is used, the annual charge per acre is 8.41 man-hours and 15.10 horse-hours, or a cost of $4.37 per acre, for cultivation.

In the hay-managed orchards two to three cuttings of alfalfa usually are made during the season.

TABLE XXIV.—*Percentage of orchardists making cultivations and the time chargeable per acre in 21 orchards under mulch-crop management in the North Yakima district.*

Operation.	Per cent of orchardists making various cultivations.	Hours per acre.		Per cent of total cultivation.
		Man.	Horse.	
Plowing	52.38	1.56	3.12	.....
Cultivation:				
Before first irrigation	90.48	4.19	7.31	80.58
Following first irrigation	19.05	.41	.69	7.88
Following second irrigation	14.29	.28	.56	5.39
Following third irrigation	14.29	.32	.64	6.15
Total	.....	5.20	9.20	100.00
Furrowing:				
Before first irrigation	.....	1.92	2.76	.....
Before second irrigation	.....	.25	.30	.....
Before third irrigation	.....	.09	.15	.....
Before fourth irrigation	.....	.09	.15	.....
Before fifth irrigation	.....	.....	.....	.....
Before sixth irrigation	.....	.12	.12	.....
Total	.....	2.47	3.48	.....

TABLE XXV.—*Percentage of orchardists making cultivations and the time chargeable per acre in 24 orchards under mulch-crop management in the Zillah district.*

Operation.	Per cent of orchardists making various cultivations.	Hours per acre.		Per cent of total cultivation.
		Man.	Horse.	
Plowing	41.67	0.84	1.68	.....
Cultivation:				
Before first irrigation	62.50	3.09	6.18	79.23
Following first irrigation	20.83	.39	.78	10.00
Following second irrigation	8.33	.20	.40	5.13
Following third irrigation	8.33	.22	.43	5.64
Total	.....	3.90	7.79	100.00
Furrowing:				
Before first irrigation	.....	1.64	2.66	.....
Before second irrigation	.....	.55	.99	.....
Before third irrigation	.....	.43	.73	.....
Before fourth irrigation	.....	.27	.52	.....
Before fifth irrigation	.....	.06	.12	.....
Total	.....	2.95	5.02	.....

The hay which is cut from the orchards is used generally for feed on the ranch. Many of the orchardists do not believe that this hay is as valuable for feeding purposes as alfalfa grown in the open field.

Table XXVI shows the prorated charge for harvesting the mulch crop, where all records are considered.

Considering all the records under mulch-crop management, the total annual labor charge per acre is $10.13. This includes cultivation, sowing, and harvesting of the mulch crop. Adding the cost of

the seed makes $10.46 as a total annual labor and material charge per acre. There is an annual acre credit of $14.26 for the hay removed from the orchard and the value of the alfalfa when used in the orchard as a pasture. (See Pl. V.)

TABLE XXVI.—*Prorated charge for harvesting the mulch crop where 45 records are considered.*

District.	Number of records.	Per acre.				Value of hay.
		Man-hours.	Horse-hours.	Cost.	Yield in tons.	
North Yakima	21	24.76	12.80	$8.11	2.19	$16.58
Zillah	24	9.57	8.30	3.64	1.15	12.23
North Yakima and Zillah	45	16.66	10.40	5.73	1.63	14.26

The estimated value per ton of hay given by the ranchers varies from $5 to $10. The majority in the North Yakima district, however, gave a value of approximately $8 per ton, those in the Zillah district gave a value of approximately $6 per ton. The estimated pasture value given in both districts varies considerably. However, the average value in the Zillah district, where a considerable number of men used a portion or all of their orchards for pasture, was estimated at approximately $10 per acre. (See Pl. V.) Where the 45 orchards under mulch-crop management are considered, the total annual labor and material charge is $10.46 per acre. The total annual hay and pasture credit is $14.26 per acre. Considering these two figures, the annual net credit is $3.80 per acre, or $0.0095 per box, on the 45 orchards under mulch-crop mangement. (See Table XXVII.)

TABLE XXVII.—*Annual prorated labor charge per acre up to harvesting time on 45 orchards in which alfalfa is used as a mulch crop.*

Operation, material, and credit.	Per acre.			Cost per box.
	Man-hours.	Horse-hours.	Cost.	
Cultivation	8.41	15.10	$4.37	$0.0110
Sowing mulch crop	.12		.03	.0001
Harvesting mulch crop	16.66	10.40	5.73	.0144
Total labor cost	25.19	25.50	10.13	.0255
Seed			.33	.0008
Total labor and material cost	25.19	25.50	10.46	.0263
Hay and pasture credit			14.26	.0358
Net credit			3.80	.0095

FURROWING.

Furrowing is a method of putting small furrows or "creases" in the orchards for the purpose of distributing the irrigation water. (See Pl. VI.) The most common implements used are the 6-foot

PASTURING SHEEP ON ALFALFA IN A YOUNG APPLE ORCHARD.

This is a common practice during October and November in this section.

IRRIGATING A 5-YEAR-OLD WINESAP ORCHARD NEAR NORTH YAKIMA, WASH.

In young orchards three furrows are often all that are necessary.

cultivator, shovel plow, and alfalfa marker. The cultivator and shovel plow are used most commonly in the North Yakima district. When the cultivator, which is usually 6 feet in width, is used for making creases, three shovels are attached—one at each end and one in the middle. A man and team constitute the crew. The trees of the valley are so set that with this implement six furrows 3 feet apart may be made comfortably in the space between the tree rows. These small furrows, usually four to six between tree rows, are 4 to 6 inches in depth. Often one or two cultivator teeth are placed between the shovels to loosen the soil between the furrows as they are being made. The 6- or 8-inch shovel plow is used by many orchardists, with either one or two horses. Where the trees are close together or the branches hang low, it often is necessary for one man to devote his entire attention to the plow while another man leads the horse. Orchardists often use a 1-horse shovel plow for making one or two furrows close to the tree row and then use either a 2-horse shovel plow or a 6-foot cultivator for making the other furrows. Ordinarily fewer creases are made between tree rows when the shovel plow is used than when the cultivator is used.

The alfalfa marker is a homemade implement. It is made by attaching a 4-inch shovel to the end of a 4 by 4 from 2 to 3 feet in length. Upon this 4 by 4 is made a platform on which the operator may ride. The small 4-inch shovel at the front end of the 4 by 4 breaks the soil as it is drawn by the team and the weight of the operator upon the platform forces the 4 by 4 into the ground, making a suitable furrow. The edges of the 4 by 4 which enter the ground are usually planed so that it will pass through the soil more easily. This implement is used most commonly in making furrows in alfalfa in the Zillah district.

The importance of furrowing in all clean-cultivated orchards of the valley is shown by the fact that its cost constitutes more than 20 per cent of the total cost of cultivation, exclusive of plowing. Records were obtained from 75 orchards under clean tillage, 74 of which practiced irrigation.

Furrows are made following each cultivation and before each irrigation until along in the midsummer, when cultivation ceases. After this last cultivation it is usually necessary to make only one set of furrows for any subsequent irrigations. Of the 74 orchardists in question, 12 made five creasings, 33 made four, 22 made three, 6 made two, and 1 made one.

In the clean-cultivated orchards 28 orchardists used the 6-foot cultivator and 41 the shovel plow (28 with a crew of one man and one horse and 13 with one man and two horses); 2 used the alfalfa marker, and 3, miscellaneous implements.

The most economical method of making furrows is with the 6-foot cultivator, using a crew of one man and two horses. (See fig. 6.) This crew will cover 9.9 acres in 10 hours, making the usual number of furrows, six, at a cost of $0.55 per acre. A little more time is required to make the furrows with the same size crew using a shovel plow, although fewer furrows are to be made between rows. A crew of one man and one horse with a shovel plow making the usual number of furrows, four, will cover 6.02 acres in 10 hours, at a cost of $0.67 per acre. Table XXVIII gives the average number of acres creased in 10 hours with different implements and crews.

FIG. 6.—Furrowing out ditches for irrigating in a 4-year-old orchard in the Nob Hill section. The scarcity of leaves near the tops of the branches is due to rosette, a disease brought about by soil conditions.

TABLE XXVIII.—*Average number of acres creased with different crews and implements in 10 hours and the cost per acre.*

Implement.	Clean-cultural management.						Mulch-crop management.					
	Number of records.	Number of furrows.	Man.	Horse.	Acres in 10 hours.	Cost per acre.	Number of records.	Number of furrows.	Man.	Horse.	Acres in 10 hours.	Cost per acre.
6-foot cultivator	28	6	1	2	9.90	$0.55	5	6	1	2	10.99	$0.50
Shovel-plow	28	4	1	1	6.02	.67	16	5	1	1	5.75	.70
Do	13	5	1	2	7.30	.75	18	5	1	2	5.59	.98

Considering all records under clean-cultural management, whatever implement or crew is used, the annual charge for all creasings is 4.79 man-hours and 7.23 horse-hours per acre, at a cost of $2.27.

In the mulch-crop orchards of the Yakima district the annual charge for creasing is about 30 per cent of the total cultivation cost, exclusive of plowing, while in the Zillah district it is approximately 41 per cent. This difference is due to the fact that more cultivation is given alfalfa orchards of the Yakima district than those in the Zillah district.

In the mulch-crop orchards the number of creasings made varied considerably, just as was the case with the clean-cultivation orchards. However, the majority of men make only one creasing and this immediately following the early spring cultivation. A few, however, practice replacing the furrows after each cutting of alfalfa. Exceptions to this are noted, for 1 orchardist made five and 5 made four creasings. There were, however, 32 who made one, 5 who made two, and 2 who made three creasings in the orchards under mulch-crop management. It is often necessary to make extra creasings where orchards are constantly pastured, especially with hogs, which damage the furrows to a considerable extent.

The shovel-plow is the most common implement used in making furrows in the mulch-crop orchards in the valley. In the Yakima district it is customary to use a crew of one man and one horse, while in the Zillah district it is most common to use a crew on one man and two horses.

Considering all growers using mulch-crop management, 5 used the 6-foot cultivator for making creases, 36 used a shovel-plow, and 4 an alfalfa marker. So very few men used the 6-foot cultivator that the cost of making furrows with that implement in the mulch-crop orchards is not comparable with the cost where the same implement is used in clean-cultivated orchards. However, there were enough shovel-plow records to make figures for that implement comparable. Referring to Table XXIX, it would seem that in both cases the cost of making furrows in the mulch-crop orchards is somewhat lower than in the orchards under clean-cultural management. Considering all records under mulch-crop management, the total charge for creasing is 2.73 man-hours and 4.30 horse-hours per acre, at a cost of $1.33.

TABLE XXIX.—*Total man-hours and horse-hours chargeable and the cost per acre for all creasings where 120 records are considered.*

District.	Clean-cultural management.			Mulch-crop management.		
	Man-hours.	Horse-hours.	Cost per acre.	Man-hours.	Horse-hours.	Cost per acre.
North Yakima	5.12	7.83	$2.45	2.47	3.48	$1.14
Zillah	4.34	6.42	2.05	2.95	5.02	1.49
North Yakima and Zillah	4.79	7.23	2.27	2.73	4.30	1.33

In the North Yakima district the principal sources of water supply for irrigation are the Naches River and Cowiche Creek. The water is brought to various parts of the district through canals or ditches, from which it is led through open ditches to the individual ranches, where it is distributed through the orchards by means of furrows. (See Pl. VI.)

Private pipe lines for the purpose of conserving as much water as possible have been installed in some instances by individual growers, particularly on the higher lands in the Nob Hill district, and there is a growing tendency on the part of the ranchers in the North Yakima district to follow this custom. This practice has nothing to do with the general maintenance of the canal as a whole, and the expense, which obviously will vary greatly, is borne entirely by the individual owners. In this study such an investment is considered as part of the land and improvement value.

The basis of water distribution under the different ditches varies from 33 to 80 acres per second-foot, and all stockholders under a given canal pay exactly the same assessments for the same amount of water. In some instances growers may use less water per acre than usual on a larger amount of land—that is, one-half inch (miner's) per acre instead of 1 inch per acre. This, however, is the exception. The customary rate of distribution is as given above in the second-foot.

In the Zillah district the majority of ranchers received their supply of irrigation water through a Government canal, known locally as the Sunnyside Canal. The water is delivered from the main ditch through open ditches or wooden flumes to the ranches. Flumes are often used in the orchards and usually are placed along the higher parts or ridges of the land so that the water may be distributed more easily throughout the orchard.

These flumes in the orchard are temporary and can be removed to permit cultivation or other orchard operations. Usually they are made of 8- to 12-inch boards, ½ to 1 inch thick, and of varying lengths. Along these boxlike forms or flumes holes are made through which the water is allowed to flow for distribution. These holes usually are covered with a small piece of tin or lath, which is used to regulate the flow of water. There is a tendency in some instances in this district to substitute underground piping for open ditches and flumes. The water in both the North Yakima and Zillah districts is distributed through the orchard by means of furrows. Very few orchardists in the valley practice the flooding method.

The maintenance charge or water tax may vary greatly from year to year. Often high assessments are made for permanent improvements or to cover the expense of litigation. The ranchers in the North Yakima district from whom data were obtained paid annually

a water tax from $0.75 to $6 per acre. The prorata[1] cost in this district for water tax is $3.10 per acre. The maintenance charge or tax per acre in the Zillah district on the Government ditch is $1. The prorata cost in this district for water tax is $0.86 per acre. The unit of measure for water is an inch (miner's) per acre. The average prorata maintenance charge per acre for water in the valley (120 records) is $2.06.

TABLE XXX.—*Time chargeable and the labor cost per acre for irrigation on 120 orchards of different acreages in Yakima Valley.*

Acres in orchard.	North Yakima district.				Zillah district.				North Yakima and Zillah districts.			
	Number of records.	Number of irrigations.	Man-hours.	Cost per acre.	Number of records.	Number of irrigations.	Man-hours.	Cost per acre.	Number of records.	Number of irrigations.	Man-hours.	Cost per acre.
1–5	46	4.62	21.65	$5.41	20	3.50	17.83	$4.46	66	4.28	20.49	$5.12
6–10	14	4.43	13.54	3.39	24	4.00	14.43	3.61	38	4.16	14.10	3.53
11–20	4	3.75	14.92	3.73	12	3.42	12.84	3.21	16	3.50	13.36	3.34
1–20	64	4.52	19.45	4.86	56	3.70	15.30	3.83	120	4.14	17.52	4.38

The first irrigation on apple orchards in the valley is made usually in the latter part of April or the first part of May, depending to a great extent on the moisture present in the soil. The number of irrigations made by the individual ranchers varies considerably throughout the valley. An irrigation is made usually every four to six weeks throughout the season, in both clean and mulch-crop orchards, some men irrigating as late as the 1st of September. Data for the North Yakima district show an average of 4.52 irrigations, and for the Zillah district an average of 3.70 irrigations.

The water is allowed to run in one place in the orchard from 24 to 72 hours, the time varying to a considerable extent with the type of soil. Usually the water is kept running till the widening zones of saturation meet between furrows. The length of time the water is allowed on one place is governed also by the head of water in the ditch. At the time of the first irrigation it often requires a longer period to saturate the soil than later. The length of time for each irrigation is governed also to a considerable extent by the contour of the land, which in turn governs somewhat the length of the furrows used for carrying the water. On hilly lands the length of the ditches is reduced to avoid washing of the soil. An orchardist may have to spend all of his time on irrigation the first few days early in the season, but on the average it requires for the season but from one to three hours per day on the average-size apple orchard in the Yakima Valley. Table XXXI gives the labor cost and the pro rata cost for water maintenance.

[1] "Prorata" cost is the actual cost distributed over all records.

The comparatively large cost reported for the mulch-crop orchards in the North Yakima district is due to the fact that a larger number of the ranches happened to be on a ditch where the cost of water maintenance is high. In the Zillah district the charge for water on the Sunnyside Canal is less than for most of the ditches in the North Yakima district. The difference here in the cost of maintenance between the mulch-crop and clean-cultural orchards is due to the fact that many orchardists practicing clean-cultural management from whom data were obtained are on the Konawak Canal and have a free water right. There is little difference between the number of irrigations made on mulch-crop and on clean-cultural orchards, although there seems to be a slight tendency (see Table XXXI) to make more irrigations on the mulch-crop orchards. More labor, however, is expended in looking after the irrigation on clean-cultural than on mulch-crop orchards. Table XXX brings out the fact that in both the North Yakima and Zillah districts more time is used in examining the ditches and regulating the water on the small than on the large orchards.

Considering the records from both clean and mulch-crop orchards in the North Yakima district, there is an average of 4.52 irrigations, requiring 19.45 man-hours per acre, at a cost of $4.86; while in the Zillah district there is an average of 3.70 irrigations, requiring 15.30 man-hours per acre, at a cost of $3.83. For the entire valley the records show an average of 4.14 irrigations, requiring 17.52 man-hours per acre, at a cost of $4.38.

TABLE XXXI.—*Time chargeable for irrigation and pro rata water tax per acre for 120 farms in Yakima Valley.*

Management.	North Yakima district.					Zillah district.				
	Number of irrigations.	Man-hours.	Labor cost.	Water tax.	Total cost.	Number of irrigations.	Man-hours.	Labor cost.	Water tax.	Total cost.
Clean cultural	4.50	20.30	$5.08	$2.66	$7.74	3.66	16.07	$4.02	$0.81	$4.83
Mulch crop	4.57	17.72	4.43	4.01	8.44	3.80	14.28	3.57	.92	4.49
Combined	4.52	19.45	4.86	3.10	7.96	3.70	15.30	3.83	.86	4.69

Management.	North Yakima and Zillah districts.				
	Number of irrigations.	Man-hours.	Labor cost.	Water tax.	Total cost.
Clean cultural	4.14	18.50	$4.63	$1.87	$6.50
Mulch crop	4.13	15.89	3.97	2.36	6.33
Combined	4.14	17.52	4.38	2.06	6.44

THINNING.

Thinning is an annual practice of all orchardists visited in the valley. (See fig. 7.) Usually it is begun during the month of June, shortly after what is known as the "June drop." The time required for this operation varies much, depending on the size of the crop, the variety, age, and size of tree, and the method adopted in thinning.

The usual practice is to thin so that the fruit is well distributed over the tree. No set rule can be given, although the growers aim to leave only one apple in a place, partly for the reason that where two apples touch each other a favorite opportunity is offered for the codling-moth larva to work. The amount of thinning depends to a

FIG. 7.—Thinning a 7-year-old Winesap tree in the Zillah district. Alfalfa is used as an intercrop and mulch crop here. Note the size of tree for its age.

considerable extent upon the season. If the crop is light and the apples are borne in clusters, two apples sometimes are left in a place; but with a heavy crop and varieties which tend to small size, many make a practice of thinning to 6 or 8 inches. Needless to say, with a large crop the work of thinning will be doubled or even trebled. Many times it is necessary to do more than one thinning during the season, this being especially true of red varieties. Practically all thinning throughout the valley is done with thinning shears. The trees are of such size and age that most of the work may be done from the ground or from an 8- to 10-foot stepladder.

The amount of thinning is governed not only by the size of the crop but by the amount of pruning that is done. The cost of thinning operations in the valley is 18.38 per cent of the total gross labor cost

previous to harvesting time, and second only to the cost of pruning, which is 19.55 per cent. Considering all the records in the Yakima district, the thinning cost is 13.81 per cent of the total gross labor cost up to harvesting time, and in the Zillah district it is 23.22 per cent.

TABLE XXXII.—*Cost of thinning in orchards in the Yakima Valley.*

District.	Number of records.	Average number of acres in orchard.	Trees per acre.	Man-hours per acre.	Cost.		
					Per acre.	Per tree.	Per box.
Under clean-cultural management:							
North Yakima	43	5.49	79.21	37.34	$9.33	$0.12	$0.0196
Zillah	32	7.70	69.07	72.43	18.11	.26	.0430
North Yakima and Zillah	75	6.44	74.88	52.31	13.08	.17	.0289
Under mulch-crop management:							
North Yakima	21	4.52	76.26	32.51	8.13	.11	.0187
Zillah	24	7.85	67.03	55.04	13.76	.21	.0375
North Yakima and Zillah	45	6.30	71.33	44.53	11.13	.16	.0280
All orchards:							
North Yakima	64	5.18	78.24	35.76	8.94	.11	.0190
Zillah	56	7.77	68.19	64.98	16.24	.24	.0410
North Yakima and Zillah	120	6.39	73.55	49.39	12.35	.17	.0286

It would seem from Table XXXII that thinning is done more thoroughly in the Zillah district than elsewhere in the valley. This fact is borne out by the propping tables, which show that propping takes more time in the North Yakima than in the Zillah district. The men in the Zillah district thin as thoroughly as possible in order to obviate a considerable amount of propping.

The amount of thinning required on the clean-cultivated orchards is more than that on the orchards under mulch-crop management. No doubt this is due to the larger yield of the orchards under the former method of management.

Considering all orchards from which data were obtained in the valley, an average of 49.39 man-hours is required for thinning, at a cost of $12.35 per acre, or $0.0286 per box.

PROPPING.

Propping is an annual practice of 60 per cent of the orchardists from whom records were obtained. It is governed to a great extent by the amount of pruning and thinning done. Most of the orchardists are beginning to make a more thorough thinning in order to obviate the necessity of so much propping. This, as has been noted, is especially true in the Zillah district. The cost of thinning for the Zillah district is more than twice as large as that for the North Yakima district, but the cost of propping is much lower. It was found that 75 per cent of the orchardists under consideration in the North Yakima district practice some propping each year, but only 43 per cent followed the practice in the Zillah district.

Propping (see Table XXXIII) is done any time throughout the latter part of the growing season when the weight of the fruit has a tendency to bear the limbs down so that there is danger of their breaking. The props usually are made of 2- by 3-inch or 1- by 4-inch strips between 8 and 12 feet in length, so notched at one end as to hold up the limbs securely. The propping is done as the need presents itself. Pine and fir props may be obtained for $15 to $20 per thousand feet. The amount of depreciation will vary to a considerable extent, depending upon the care given them. Many of the growers believe that, with proper handling and shelter, these props would last from 10 to 15 years.

TABLE XXXIII.—*Number of man-hours and horse-hours and cost per acre required for propping orchards in the Yakima Valley.*

District.	Number of records.	Per acre.				Cost per tree.	Per cent propping.
		Trees.	Number of man-hours.	Number of horse-hours.	Cost.		
Under clean-cultural management:							
North Yakima	43	79.2	5.32	4.61	$2.02	$0.026	79.07
Zillah	32	69.1	2.93	3.12	1.20	.017	50.00
North Yakima and Zillah	75	74.9	4.30	3.98	1.67	.022	66.67
Under mulch-crop management:							
North Yakima	21	76.3	4.85	3.99	1.81	.024	66.67
Zillah	24	67.0	2.65	2.51	1.04	.016	33.33
North Yakima and Zillah	45	71.3	3.67	3.20	1.40	.020	44.44
All orchards:							
North Yakima	64	78.2	5.16	4.41	1.95	.025	75.00
Zillah	56	68.2	2.81	2.86	1.13	.017	42.86
North Yakima and Zillah	120	73.6	4.06	3.69	1.57	.021	60.00

Several methods of handling props are practiced. On smaller plantings some men carry their props into the orchard and prop where needed. Others use a team for hauling out the props, placing them in convenient piles throughout the orchard. Setting up props is a separate operation. Many of the men haul the props out and set them as the hauling is being done. When these props are hauled, a crew of one man and two horses is used ordinarily. So few men followed any one particular method that it is impossible to give a fair average for any particular crew in performing this operation.

As a rule, after the season is over the props are hauled and piled in a sheltered place. Few men allow their props to remain in the orchard. A little more time is required for this operation in the clean-cultured than in the mulch-crop orchards, owing mostly to the difference in yield.

Considering all records that were taken, regardless of the method used, the annual propping charge is 4.06 man-hours and 3.69 horse-hours, at a cost of $1.57 per acre.

SPRAYING.

Spraying is an annual practice. The need of careful and systematic spraying is felt by practically all the growers of the valley, for it is realized that only by persistently following such practice can the production of marketable apples be guaranteed. The average spraying cost of labor and material for all of the orchardists considered in this study is $25.14 per acre, or 7.27 per cent of the net cost of production.

The orchardists considered in this investigation make an average of four sprays per year. Some make as many as seven applications, the number varying with the abundance of insect pests and the prevalence of fungus diseases. The majority of growers make a dormant or lime-sulphur spray and three lead-arsenate sprays.

The codling moth is one of the worst pests with which the orchardists in the valley have to contend. For this reason a few of the orchardists practice making two calyx sprays, one immediately following the other. This is done because of the irregularity in blossoming of the different varieties and also to make a more thorough application of material for protection against the codling-moth larvæ.

It is the practice of most growers to make lead-arsenate sprays only on trees which promise to yield part or the whole of a crop. Often small strips of rags, or markers, are tied to the trees which are to be sprayed. In this way considerable time can be saved. However, this practice may result in the survival of a number of codling-moth larvæ in the unsprayed trees.

On account of the appearance of the apple powdery-mildew, a few of the orchardists are beginning to use atomic sulphur for its control. In some years also the apple aphids cause considerable damage. A few of the growers use tobacco extract, whale-oil soap, and other contact sprays for their control, but a spray of this kind was not general at the time of this study.

Since so few growers were making an annual practice of applying any material for the control of apple powdery-mildew or aphis, no discussion is made of methods practiced. However, the cost of these sprays is taken into account where they are made and is given in Table XXXVI.

It would seem from conditions prevalent at the time of the study that the growers of the valley will find it necessary to use some preventive measures against both the apple powdery-mildew and the aphis.

The spraying crew usually consists of three men and two horses. In the North Yakima district 55 of the 64 orchardists used such a crew, 7 used a crew of two men and two horses, 1 a crew of two men and one horse, and 1 man used a stationary engine and pump. In the last case the orchard contained 3 acres and the operator himself did all the spraying.

In the Zillah district, 50 orchardists visited used for spraying a crew of three men and two horses, 5 a crew of two men and two horses, and 1 a crew of four men and two horses. In the valley as a whole, 105 used a crew of three men and two horses in spraying. With this crew, one man usually does the driving and tends the engine, leaving one man for each lead of hose to do the spraying. Since most of the orchardists used a crew of three men and two horses, *all the discussion on spraying will pertain to an outfit with this number in the crew unless otherwise stated.*

Gasoline engines used for spraying purposes vary from 1½ to 4 horsepower. The complete outfit usually consists of a gasoline engine, a spray tank varying in capacity from 150 to 200 gallons, and two 50-foot leads of spray hose. Bamboo rods with a single nozzle attachment complete the outfit. But few orchardists use two nozzles on a lead. Nozzles of the Bordeaux type are the most popular and a pressure of 200 to 300 pounds is used ordinarily in making all sprays. Few growers feel the necessity of using a spray tower, although the use of towers is encouraged.

Eighty-three of the growers considered in this investigation owned spray outfits and 37 hired their spraying done. Where spraying was hired, $1 an hour was paid for the spray outfit, team and one operator. Considering the man- and horse-labor at $0.25 and $0.15 per hour, respectively, there is left a machine charge of $0.45 per hour. The machine-hours per acre for hired outfits are 9.62, and the machine cost per acre $4.33.

The owned spray outfits are considered as a part of the farm equipment and the annual charge for their use is included in the equipment charge, while the machine charge for hired outfits is given as a separate item. Both appear under fixed costs.

DORMANT SPRAY.

A dormant or lime-sulphur spray is made usually in the latter part of March or the 1st of April. Many of the orchardists have a tendency to delay this spray until the fruit buds begin to show their green tips. This spray is made usually with a 1–10 solution—that is, 1 gallon of concentrated solution of lime and sulphur to 10 gallons of water. A number of the orchardists are beginning to use miscible oils for the dormant spray.

All orchardists visited in the valley make the dormant spray. Of the 105 who used a crew of three men and two horses, 69 own spray outfits and 36 hire their spraying done. (See Table XXXIV.) By referring to Table XXXIV, in the lime-sulphur spray, it will be noted that the former spray about an acre less per day and apply nearly 80 gallons more per acre than the latter, making a total labor and material cost of $2.03 more per acre for those who own their outfits than those who hire.

Twenty-five orchardists in the North Yakima district spray with their own outfits and 30 hire their spraying done, while in the Zillah district 44 spray with their own outfits and 6 hire their spraying done.

TABLE XXXIV.—*Summary of spraying with a crew of three men and two horses, with owned and hired spray rigs, on 105 farms studied in the Yakima Valley.*

OWNED SPRAY RIGS.

District and spray.	Number making sprays.	Acres in 10 hours.	Gallons.		Cost.		
			Per acre.	Per tree.	Labor.	Material.	Total.
North Yakima:							
Lime-sulphur	25	3.24	479.62	6.44	$3.24	$6.86	$10.10
Calyx or first lead-arsenate	25	3.37	486.82	6.53	3.12	1.70	4.82
Second lead-arsenate	21	3.58	411.04	5.50	2.93	1.43	4.36
Third lead-arsenate	15	4.36	315.90	4.18	2.41	1.15	3.56
Fourth lead-arsenate	25	3.74	401.01	5.38	2.81	1.41	4.22
Fifth lead-arsenate	8	3.29	419.38	5.41	3.19	1.62	4.81
Zillah:							
Lime-sulphur	44	3.41	464.31	6.84	3.08	6.61	9.69
Calyx or first lead-arsenate	44	3.57	483.32	7.21	2.95	2.01	4.96
Second lead-arsenate	33	3.77	459.87	6.81	2.79	1.85	4.64
Third lead-arsenate	41	3.72	447.15	6.56	2.82	1.82	4.64
Fourth lead-arsenate	44	3.81	432.26	6.45	2.75	1.75	4.50
Fifth lead-arsenate	27	4.14	399.79	5.82	2.53	1.66	4.19
Sixth lead-arsenate	6	5.15	301.07	4.57	2.04	2.03	4.07
North Yakima and Zillah:							
Lime-sulphur	69	3.34	469.87	6.68	3.14	6.70	9.84
Calyx or first lead-arsenate	69	3.49	484.59	6.95	3.01	1.90	4.91
Second lead-arsenate	54	3.69	440.88	6.27	2.85	1.71	4.56
Third lead-arsenate	56	3.88	411.99	5.87	2.71	1.64	4.35
Fourth lead-arsenate	69	3.79	420.93	6.04	2.77	1.63	4.40
Fifth lead-arsenate	35	3.91	404.27	5.72	2.68	1.65	4.33
Sixth lead-arsenate	6	5.15	301.07	4.57	2.04	2.03	4.07

HIRED SPRAY RIGS.

North Yakima:							
Lime-sulphur	30	4.38	397.97	4.88	$2.40	$5.50	$7.90
Calyx or first lead-arsenate	30	4.50	408.22	5.01	2.33	1.42	3.75
Second lead arsenate	24	5.59	332.71	4.09	1.88	1.08	2.96
Third lead-arsenate	14	4.87	365.76	4.43	2.16	1.34	3.50
Fourth lead arsenate	28	5.26	335.05	4.12	2.00	1.13	3.13
Fifth lead-arsenate	6	4.25	382.78	4.26	2.47	1.43	3.90
Zillah:							
Lime-sulphur	6	4.24	353.71	4.50	2.48	4.73	7.21
Calyx or first lead-arsenate	6	4.65	318.43	4.05	2.26	1.36	3.62
Second lead-arsenate	4	4.42	382.16	4.42	2.37	1.64	4.01
Third lead-arsenate	3	6.01	239.63	3.20	1.75	1.14	2.89
Fourth lead-arsenate	6	4.75	338.80	4.31	2.21	1.48	3.69
Fifth lead-arsenate	4	4.72	321.69	3.66	2.23	1.32	3.55
Sixth lead-arsenate	2	8.93	155.88	1.63	1.18	.84	2.02
North Yakima and Zillah:							
Lime-sulphur	36	4.35	390.59	4.82	2.41	5.40	7.81
Calyx or first lead-arsenate	36	4.52	393.26	4.85	2.32	1.41	3.73
Second lead-arsenate	28	5.39	339.67	4.14	1.95	1.16	3.11
Third lead-arsenate	17	5.03	343.50	4.23	2.09	1.31	3.40
Fourth lead-arsenate	34	5.16	335.71	4.15	2.03	1.19	3.22
Fifth lead-arsenate	10	4.42	358.34	4.03	2.37	1.38	3.75
Sixth lead-arsenate	2	8.93	155.88	1.63	1.18	.84	2.02

Considering all records in the valley, regardless of crew or whether the spray outfit is owned or hired, the total labor and material cost for the lime-sulphur spray is $8.81 per acre, or 35.04 per cent of the total labor and material spraying cost. (See Table XXXVI.)

LEAD-ARSENATE SPRAYS.

Usually three or four lead-arsenate sprays are made for the control of the codling moth. Some growers find it necessary to make as many as six sprays. Throughout the valley there is considerable variation in the time that the calyx spray is applied. This is due primarily to differences in altitude and season. In 1913 it was applied between April 22 and 27; in 1914, April 20 and 25; in 1915, April 25 and 30; and in 1916, April 27 and May 2. Lead-arsenate paste is used by the majority of orchardists for these sprays. From 1½ to 3 pounds of this paste is used in 50 gallons of water.

The calyx or first lead-arsenate spray.—The calyx spray is considered by the majority of orchardists to be the most important. All make it about the time that 75 to 90 per cent of the petals have fallen. By referring to Table XXXIV it will be seen that the same number of owned and hired outfits were used in this spray as in the dormant spray. The former averaged about an acre less in 10 hours and applied about 90 gallons per acre more than the latter, making a total labor and material cost of $1.18 more per acre for those who own outfits than those who hire. More material is usually applied per tree in this spray than in any of the others, at least by the better class of commercial growers. The total labor and material cost per acre for the calyx spray in the North Yakima district (55 orchards) was $4.24, while in the Zillah district (50 orchards) it was $4.77. Considering all records, whatever size of crew or whether the spray outfit is owned or hired, the total labor and material cost per acre for the calyx spray was $4.47, or 17.78 per cent of the total labor and material spraying cost. (See Table XXXVI.)

Second lead-arsenate spray.—The second lead-arsenate spray is usually made from three to four weeks after the calyx spray. The date of application will vary with the season. It is usually between the 11th and the 25th of May, but sometimes as late as the first of June. The purpose is to poison the codling-moth larvæ, which are beginning to hatch at this time. This spray was made by 78 per cent of the growers considered in this investigation. As in the former sprays, it will be seen that the cost per acre for labor and material is greater for those who own their outfits than those who hire, and that more of the orchardists in the North Yakima district hire their spraying done. The total labor and material cost for the North Yakima district (45 orchards) was $3.64 per acre; while in the Zillah district (37 orchards) it was $4.57. Considering all records, regardless of crew or whether the spray outfit is owned or hired, the total labor and material cost per acre for the second lead-arsenate spray was $3.09, or 12.29 per cent of the total labor and material spraying cost. (See Table XXXVI.)

Third lead-arsenate spray.—The third lead-arsenate spray is made from 10 to 15 days after the second codling-moth spray. This spray was made by 72 per cent of the growers visited. In this spray, as in the second lead-arsenate, there is about an acre more done per day by hired than by owned outfits, but less material is applied per acre. It is obvious from the figures that the difference in cost between the owned and hired outfits in this spray is somewhat less than in the former sprays. The necessity of a thorough application of material is not felt so keenly by the growers as in the previous sprays, for up to and including this spray there is a gradual increase in the amount of ground covered per day, and a decrease in the material applied per acre, especially where the spraying is done by the owners themselves. The total labor and material cost for the North Yakima district (29 orchards) was $3.53; while in the Zillah district (44 orchards) it was $4.52 per acre. Considering all records, regardless of crew used or whether the spray outfit is owned or hired, the total labor and material cost per acre for the third lead-arsenate spray was $2.89, or 11.50 per cent of the total labor and material spraying cost. (See Table XXXVI.)

Fourth lead-arsenate spray.—The fourth lead-arsenate spray is usually made from 9 to 10 weeks after the calyx spray. One hundred and eighteen orchardists visited, or 98 per cent, used this spray. From the number of orchardists who make this spray, together with the amount of material applied and the labor required, it appears that this spray is the second most important codling-moth spray. Table XXXIV shows the number of acres sprayed per day and the material applied per acre for both hired and owned outfits. The cost per acre for labor and material was $1.18 more for those who owned outfits than those who hired. Total labor and material cost in the North Yakima district (53 orchards) for this spray was $3.64; while in the Zillah district (50 orchards) it was $4.40. Considering all records, whatever size of crew used or whether the spray outfit is owned or hired, the total labor and material cost per acre for the fourth lead-arsenate spray was $3.85, or 15.32 per cent of the total labor and material spraying cost. (See Table XXXVI.)

Fifth lead-arsenate spray.—The time for the fifth spray is usually the early part of August. It is made by 41 per cent of the growers considered in this study. Thirty-five orchardists owning, and ten hiring outfits made this spray, each using a crew of three men and two horses. From Table XXXIV it will be seen that the cost per acre for labor and material is $0.58 more for those who own outfits than those who hire. Considering all records for the valley, regardless of crew or whether the spray outfit is owned or hired, the total labor and material cost for the fifth lead-arsenate spray was $1.74, or 6.92 per cent of the total labor and material spraying cost. (See Table XXXVI.)

Sixth lead-arsenate spray.—The sixth lead-arsenate spray, usually applied during the latter part of August or the first of September, depending upon the season, was made by 8 per cent of the growers considered in this study. Because so few of the orchardists in the valley made this spray, the comparison of the figures in Table XXXIV should not ordinarily be made. It was necessary, however, to use them in order to arrive at the total cost of spraying for these 120 records. In considering all records for the valley, whatever the size of crew, and whether the spray outfit is owned or hired, the total labor and material cost for the sixth lead-arsenate spray was $0.29, or 1.15 per cent of the total labor and material spraying cost. (See Table XXXVI.)

SUMMARY OF SPRAYING PRACTICES.

There is a tendency in the valley to make a more thorough application of material on orchards under clean-cultural management than on those under mulch-crop management. Where owned outfits are used on such orchards, more material is applied per acre, fewer acres are sprayed per day, and the average total labor and material cost is greater than where owned outfits are used on mulch-crop orchards. However, where hired outfits are used on orchards under clean-cultural management less material is applied, more acres are sprayed per day, and the total labor and material cost is less per acre than where such outfits are used on orchards under mulch-crop management. As results from the owned outfits are better as a basis for comparison, it would seem that orchards under clean-cultural management received a more thorough application of spray material. This is brought out more clearly by making a comparison of all orchards where spraying is done with owned outfits with those where hired outfits are used. (See Table XXXIV.)

It is found that for practically all the orchards studied more acres are sprayed per day with a hired outfit, less material is applied per acre, and the total labor cost is less than where the outfit is owned. Comparing the North Yakima and the Zillah districts, it is found that with owned outfits more acres are sprayed in 10 hours and more material is applied per acre and per tree in the Zillah district. Considering the 120 orchards, the average cost for spraying labor and material is $0.0256 more per box than in the North Yakima district. The pro rata labor cost for spraying, considering all records for the valley, was $12.93, and the material pro rata cost was $12.21 per acre, making a total of $25.14 per acre, or $0.0582 per box. (See Table XXXV.)

TABLE XXXV.—*Summary of spraying expenditures on 120 farms in Yakima Valley, by districts.*

Item.	North Yakima district.	Zillah district.	North Yakima and Zillah districts combined.
Man-hours per acre	31.99	42.07	36.69
Horse-hours per acre	21.78	28.85	25.08
Labor cost per acre	$11.26	$14.84	$12.93
Material cost per acre	$10.55	$14.12	$12.21
Total cost per acre	$21.81	$28.96	$25.14
Gallons of material per acre	1,773.09	2,364.69	2,049.17
Gallons of material per tree	22.67	34.67	27.84
Labor cost per box	$0.0243	$0.0372	$0.0299
Material cost per box	.0228	.0355	.0283
Total cost per box	.0471	.0727	.0582

TABLE XXXVI.—*Summary of spraying practices and pro rata cost by sprays on farms studied in Yakima Valley.*

Spray.	Number making spray.	Per acre.			Gallons.		Material cost per acre.	Total cost per acre.	Per cent of total labor and material spraying cost.
		Man-hours.	Horse-hours.	Cost.	Per acre.	Per tree.			
Lime-sulphur	120	7.89	5.37	$2.78	430.12	5.84	$6.03	$8.81	35.04
First lead-arsenate or calyx	120	7.78	5.33	2.74	454.10	6.17	1.73	4.47	17.78
Second lead-arsenate	94	5.50	3.74	1.94	309.61	4.21	1.15	3.09	12.29
Third lead-arsenate	86	5.08	3.48	1.79	282.97	3.84	1.10	2.89	11.50
Fourth lead-arsenate	118	6.90	4.72	2.43	381.03	5.18	1.42	3.85	15.32
Fifth lead-arsenate	50	3.09	2.11	1.09	164.15	2.23	.65	1.74	6.92
Sixth lead-arsenate	10	.45	.34	.16	27.19	.37	.13	.29	1.15

MISCELLANEOUS LABOR.

A certain amount of labor done on the various ranches during the year is classified as miscellaneous labor. Among the more important items are overhauling the spray outfit, scraping and doctoring the trees, cutting blight, summer pruning, cleaning of lateral ditches, cutting water spouts, and hoeing about the trees. This miscellaneous labor charge on the 75 clean-cultivated orchards was 12.09 man-hours and 0.92 horse-hour, or $3.16 per acre and $0.0070 per packed box; while in orchards under mulch-crop management this charge was 7.21 man-hours and 0.52 horse-hour, or $1.88 per acre and $0.0047 per packed box.

Considering the 120 orchards, the annual miscellaneous labor charge was $2.68 per acre or $0.0062 per packed box.

TOTAL MAINTENANCE COST.

The total maintenance labor on 43 orchards under clean-cultural management in the North Yakima district was 208.14 man-hours and 97.67 horse-hours, while on the 32 orchards under similar management in the Zillah district the charge was 241.92 man-hours and 104.03 horse-hours.

In the case of the 21 orchards under mulch-crop management in the North Yakima district the charge was 197.45 man-hours and 76.23 horse-hours, while on the 24 orchards under similar management in the Zillah district the charge was 202.76 man-hours and 74.24 horse-hours.

The net labor cost up to harvest time was 34.82 per cent of the total net labor cost in the North Yakima district, while in the Zillah district it was 38.72 per cent.

The total maintenance charge per acre on the 75 orchards under clean cultivation was 222.55 man-hours and 100.38 horse-hours, while on the 45 orchards under mulch-crop management it was 200.29 man-hours and 75.18 horse-hours.

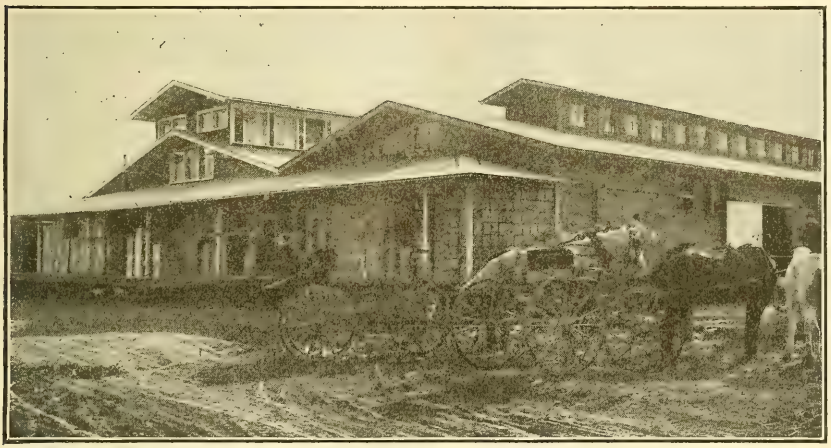


FIG. 8.—One of the larger packing sheds in the Yakima district.

Considering all records in the valley, the total net labor cost up to harvest time was $61.22 per acre, or $0.1417 per box. This is 41.08 per cent of the total net labor cost.

HANDLING THE CROP.

"Handling the crop" includes all the labor necessary to deliver it at a local association or shipping point. This labor includes the hauling of the box shook to the ranch, the making up of the box, hauling empty boxes to and full boxes from the orchard during harvesting and picking, and all packing-house labor, including sorting, packing, nailing, waiting, foreman, etc.

Twelve of the 64 orchardists visited in the North Yakima district hauled their picked apples to a local association, where they were sorted, graded, and packed at a stipulated price (see fig. 8), which included box, paper, nails, and labeling, or a complete packed box. This price ranged between $0.25 and $0.28 per packed box.

Where all records taken in the valley are considered, the total net labor cost per acre for handling was $87.79 or 25 per cent of the total annual net cost of production.

PICKING.

Picking is usually begun in the early part of September on a few early varieties, but the most intensive harvesting comes with Jonathan picking about the middle of September and continues well into November, or until the Winesaps are picked. The fruit on a tree is usually harvested with one picking. However, some orchardists make two or three pickings from the trees of the red varieties. In this way it is usually possible to get a crop of better color and size than with one picking.

All picking is done by hand. An 8- to 14-foot ladder and 18-quart picking pail or canvas bag constitute the picker's equipment. The bag is suspended directly in front of the picker by means of shoulder straps. The bottom of the bag is formed by a flap of the canvas which is held in place by a snap and ring. By unsnapping the ring the apples are allowed to roll out of the bottom of the bag into the box. The majority of growers use this type of picking sack.

TABLE XXXVII.—*Number of boxes picked in 10 hours and cost per box and per acre on the farms studied in Yakima Valley.*

District.	Clean-cultural management.				Mulch-crop management.			
	Loose boxes in 10 hours.	Cost per loose box.	Cost per packed box.	Cost per acre.	Loose boxes in 10 hours.	Cost per loose box.	Cost per packed box.	Cost per acre.
North Yakima	64.22	$0.0390	$0.0584	$27.74	66.60	$0.0376	$0.0563	$24.44
Zillah	55.71	.0449	.0673	28.33	59.81	.0418	.0627	23.01

District.	Combined management.			
	Loose boxes in 10 hours.	Cost per loose box.	Cost per packed box.	Cost per acre.
North Yakima	64.98	$0.0385	$0.0577	$26.66
Zillah	57.26	.0437	.0655	26.05

Practically all picking is done by man day labor, at the rate of from $0.225 to $0.25 per hour. A few exceptions were reported where contract picking was done at from $0.035 to $0.04 per loose box, but none of the orchardists considered in this study hired their picking done in this way. Ordinarily a man will pick between 50 and 75 loose boxes in 10 hours, varying with the crop (yield per tree), the variety, the size, the age of tree, etc.

Table XXXVII gives the variations in the number of boxes that usually are picked in a day in the North Yakima and Zillah dis-

tricts. After the apples are picked they are placed in boxes which previously have been distributed throughout the orchard at convenient places. The pickers fill the boxes without heaping, and thus one box may be piled upon another without injury to the fruit. Usually as the boxes are filled they are piled in the shade at a place conveniently located for hauling into the packing shed. In some instances "lug boxes" are used for hauling the picked fruit to the packing shed. This box is of a little heavier type than the ordinary packing box, a little wider and longer, and a little shallower, but has somewhat greater capacity than the picking box. These boxes are used mostly in some of the very large orchards. As a rule, however, orchardists considered in this investigation use the regular packing box.

FIG. 9.—Hauling box shooks to the ranch. It is the practice to haul the box shooks from the station, and make up the boxes before harvesting time at the ranch.

The yield is the greatest limiting factor in determining the amount a picker can pick in a day, but where day labor is used the variation in the amount picked is not great, owing to the attempt on the part of the picker to pick about the same number of boxes per day and at about the same cost per box regardless of the crop. (See Table XXXVIII.)

The yields averaging 200 boxes or less were on the younger orchards. Usually the apples on young trees are well placed and of good size, the trees are smaller, and there is not so much need of a ladder, so that, if the fruit is not scattered too widely, the picker often will be able to pick more in a given time than where the crop is larger though on bigger trees.

If contract labor had been employed for picking, no doubt up to a certain point the effect of the yield on the picking time would have

been more noticeable; for, no matter how large a crop may be, there is a limit to the amount of fruit the average picker is able to pick.

On the farms studied in the North Yakima district 106.62 hours were required to pick an acre yielding an average of 462 packed boxes, at a cost of $26.66, or $0.0577 per packed box; while in the Zillah district, with an average yield of 398 packed boxes per acre 104.21 hours were required, at a cost of $26.05, or $0.0655 per packed box.

In the valley as a whole, all records considered, the total charge per acre for picking, with an average yield of 432 packed boxes, was 105.50 man-hours, or $26.38, or $0.0611 per packed box.

FIG. 10.—Hauling the filled loose boxes from the orchard to the packing shed. Trucks are used on long hauls.

The cost of picking in the valley is 30.05 per cent of the total net handling cost, or 17.70 per cent of the total net annual labor cost, or 7.63 per cent of the total net annual cost of production.

TABLE XXXVIII.—*Influence of yield on picking time and cost on 120 farms in the Yakima Valley.*

Yield per acre in packed boxes.	Number of orchards.	Packed box yield per acre.	Loose boxes in 10 hours.	Cost per acre.	Cost per tree.	Cost per packed box.	Cost per loose box.
200 and under	10	164.64	66.60	$9.27	$0.14	$0.0563	$0.0375
201 to 300	18	241.49	56.57	16.02	.23	.0663	.0442
301 to 400	31	346.33	60.00	21.66	.31	.0625	.0417
401 to 500	26	448.25	63.14	26.64	.37	.0594	.0396
501 to 600	13	544.28	64.65	31.56	.38	.0580	.0387
Over 600	22	744.08	60.78	45.89	.55	.0617	.0411
All records	120	432.00	61.38	26.38	.39	.0611	.0407

HAULING BOX SHOOKS.

All growers considered in this discussion hauled box shooks to their ranches. Short hauls are made possible by spurs or sidings provided by the railways. Usually one man and two horses are used for hauling shooks. Sometimes four horses are used. (See fig. 9.) Ten orchardists, however, used one man and one horse and five used two men and two horses when hauling shooks. In the North Yakima district a crew of one man and two horses hauled an average load of 529 box shooks an average of 2.46 miles at a cost of $0.0041 per shook, or $0.0017 per shook per mile; while in the Zillah district a similar crew hauled an average load of 412 shooks an average of 1.20

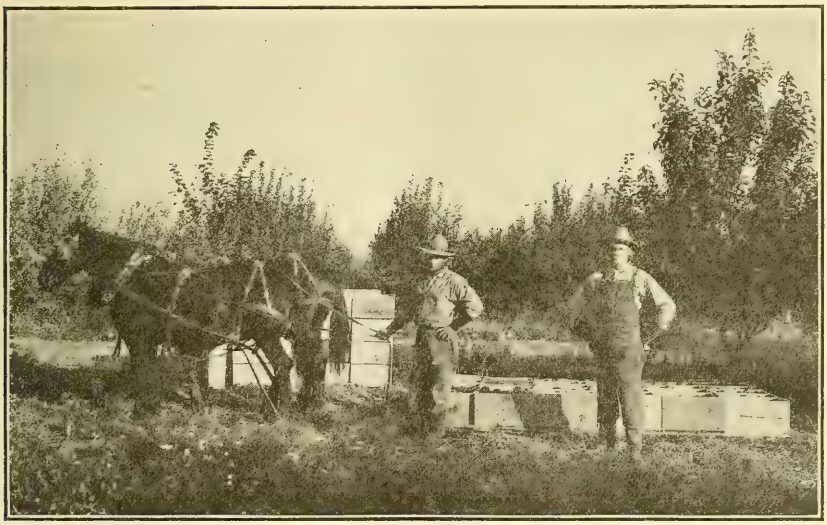


FIG. 11.—Hauling the filled loose boxes from the orchard to packing shed by means of a slip boat. Slip boats or sleds are used on short hauls.

miles, at a cost of $0.0032 per shook, or $0. 0027 per shook per mile. Considering all records in the valley, whatever the size of crew, the average distance hauled was 1.81 miles, with an average cost per shook of $0.0038 or $0.0021 per shook per mile.

MAKING BOXES.

As in other Northwestern apple-producing areas, most of the boxes are made up on the ranch at odd times before picking time or during the early part of harvesting. Much of this work is done by contract labor at $0.0065 to $0.01 per box. On m ny of the small ranches the boxes are made by the owner or members of his family. A man will make from 200 to 500 boxes per day, depending upon his expertness. In this study the charge is $0.0065 for making a box.

ORCHARD HAULING.

In the larger orchards one man is employed exclusively in orchard hauling. In the smaller orchards it is not necessary for one man to be constantly employed in hauling to and from the orchard. As a rule, the owner does the orchard hauling and either superintends the pickers or assists in the packing house when not employed in hauling. In general the orchardists here consider the hauling to and from the orchard as separate operations, and they have so been considered in this study. The majority of orchardists use a low truck wagon with one man and a team for hauling. (See fig. 10.) A few in the smaller orchards use a sled with either one man and two horses or one man and one horse. (See fig. 11.) Practically the same methods are practiced in both districts.

On the farms studied in the North Yakima district 33 orchardists used a wagon for orchard hauling, 22 had a crew of one man and two horses, and 11 had one man and one horse. Thirteen used a sled, 6 with a crew of one man and two horses and 7 with one man and one horse. There were 18 orchardists whose time of hauling to and from the orchard was lumped as one item.

On the farms studied in the Zillah district 36 orchardists used a wagon for hauling, with a crew of one man and two horses; 9 used a sled, 8 with a crew of one man and two horses and one with one man and one horse; and 4 used a wagon with two men and two horses. There were 7 whose time of hauling to and from the orchard was lumped as one item.

TABLE XXXIX.—*Comparative cost of hauling boxes to and from the orchard on a wagon or a sled when both operations are done with a crew of one man and two horses (62 farms, Yakima Valley).*

Vehicle.	Records.	Empty boxes to orchard.			Full boxes from orchard.			Total cost per loose box.	Total cost per packed box.
		Boxes per load.	Cost per loose box.	Cost per packed box.	Boxes per load.	Cost per loose box.	Cost per packed box.		
Wagon	50	91	$0.0040	$0.0061	40	$0.0093	$0.0139	$0.0133	$0.0200
Sled	12	60	.0056	.0084	20	.0119	.0179	.0175	.0263

Table XXXIX gives the average number of boxes, empty and full, hauled on a wagon or sled by a crew of one man and two horses. The total cost of hauling is somewhat larger where a sled is used. The actual average cost of 95 orchardists for hauling to the orchard, regardless of crew or method employed, was $0.0045 per empty box, or $0.0068 per packed box. Twelve of this number hauled their apples directly to a central packing house, while the average actual cost for the remaining 83 for hauling loose boxes to the packing shed on the ranch, regardless of crew or method employed, was $0.0045 per loose box or $0.0068 per packed box.

There were 25 orchards in which one man was constantly employed in hauling boxes to and from the orchard. The average cost for this operation was $0.0124 per loose box, or $0.0186 per packed box. One hundred and eight orchardists make a practice of hauling empty boxes to the orchard and full boxes to the packing house on the ranch, at a cost of $0.0216 per packed box. The orchard hauling charge, considering the 120 orchards, whatever the size of crew or method employed, was $0.0205 per packed box. (See Table XLII.)

PACKING-HOUSE LABOR.

Packing-house labor includes sorting, packing, nailing, waiting on the packers or sorters, foremen services, and any other packing-

FIG. 12.—A packing crew on a small ranch in the Yakima district. Most men pack all their fruit inside the packing house.

house labor, such as the service of truckers or men employed to handle the boxes about the packing house. (See fig. 12.) Ordinarily extra help is employed only where a large packing crew is used, the members of the family usually making up the crew.

The packing-house-labor cost for the 64 farms about North Yakima was $45.47 per acre, or $0.0984 per box, and $45.64 per acre, or $0.1147 per box, for the 56 farms about Zillah or the lower Yakima Valley. If the 120 farms studied are considered, the average cost was $45.55 per acre, or $0.1054 per box, or 30.57 per cent of the total net maintenance and handling costs. (See Table XL.)

SORTING.

The time required for sorting depends much on the variety and condition of the fruit and whether or not mechanical sizers or wipers are used. The number employed in the sorting crew depends upon the size of the crop and the method of handling. Where there are enough apples to make the use of a mechanical sizer economical, from two to six sorters usually are employed about the sorting table of the sizer. Men who do not use a sizer usually employ hands to sort the fruit for the packers from picking boxes or tables. In some cases packers sort their own apples. In most instances more sorters than packers are employed. Some growers find it necessary to use two sorters to one packer, while a few claim that one sorter will take care of two packers. A very common crew is three packers, four sorters, and one man to nail and wait on the packers and sorters. Most of the fruit in the valley is sorted and packed into three grades—"Extra Fancy," "Fancy," and "C. Grade." At the time of this study the majority of growers sorted their fruit by hand.

It was found that the average number of boxes sorted by one man in a day was 73 at North Yakima and 52 at Zillah. This difference is due largely to the fact that there is often more codling-moth injury in the Zillah district.

TABLE XL.—*Packing-house-labor costs (120 records, Yakima Valley).*

Operation.	North Yakima district (64 records.)			Zillah district (56 records).			Yakima Valley (120 records).		
	Number of records.	Cost.		Number of records.	Cost.		Number of records.	Cost.	
		Per acre.	Packed box.		Per acre.	Packed box.		Per acre.	Packed box.
Sorting	41	$16.16	$0.0341	53	$19.55	$0.0480	94	$18.07	$0.0414
Packing	45	23.82	.05	55	19.94	.05	100	21.68	.05
Sorting and packing	7	33.08	.06	1	21.00	.06	8	31.57	.06
Nailing	19	4.61	.0091	20	3.50	.0089	39	4.04	.0090
Waiting	3	5.86	.0097	8	3.29	.0084	11	3.99	.0088
Nailing and waiting	31	6.22	.0132	33	4.34	.0105	64	5.25	.0119
Foreman	6	7.22	.0132	17	4.13	.0082	23	4.94	.0096
Other packing labor	5	17.69	.0409	18	5.12	.0121	23	7.85	.0185
Packing-house labor	52	46.07	.0948	56	45.64	.1147	108	45.84	.1039
Warehouse packing	12	42.81	.1209	.....	.....	.....	12	42.81	.1209
Total packing-house-labor charge [1]	64	45.47	.0984	56	45.64	.1147	120	45.55	.1054

[1] Fifty-two orchardists handle their fruit on their own ranches, 12 handle it through an association; the 64 records combine both methods.

If all records are considered, it is found that the average sorter will sort 60 boxes in 10 hours. This refers to packed boxes, which in terms of loose boxes would be practically 90. The average cost of sorting for the 94 orchardists of the 120 studied who sort their own apples or have them sorted on the farm is $18.07 an acre, or $0.0414 per box. (See Table XL.)

Where a wiping machine is used, which in the case of these records is only in the Zillah district, the sorting cost is less than that where no such machine is used. At one end of the wiping machine the apples are fed into an endless carrier by one or more men. On either side of the carrier is a rotating cylinder covered with strips of cloth, which serve to wipe the fruit clean from spray material or dust before it reaches the sorters. It is claimed that the wiping greatly aids the sorter, enabling him readily to detect worm stings or marks. In addition to this the machine if properly handled will assure the steady flow of apples to the sorters.

Many orchardists claim that this machine is practical only where the crop is at least 2,000 boxes, although it would seem that its use would be practical for a smaller crop.

Where mechanical sizers are used, sorting is usually more rapid, for the apples are placed on a sorting table, which enables the sorters

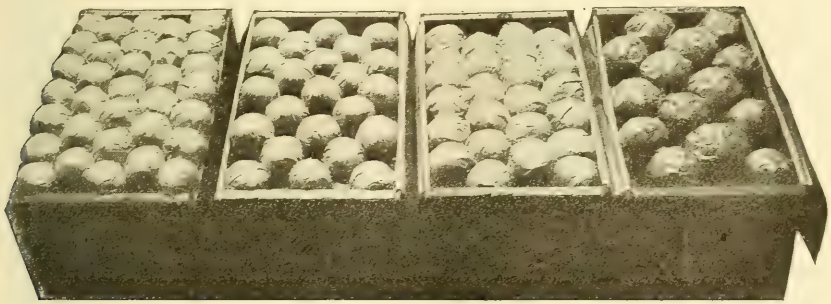


FIG. 13.—Four kinds of packs used in packing box apples. The size of apple usually determines the pack.

to work more rapidly and more conveniently. In such cases there is always one man to wait on the sorters or dump the apples on the sorting table. Mechanical sizers are coming into more general use.

PACKING.

On 100 of the 120 farms considered in this survey the growers packed their own apples. Forty-five of these men are located about North Yakima and 55 in Zillah, or the lower valley district. Packers are usually paid by the box, at from $0.03 to $0.05 per box. Both men and women are employed as packers. An average day's work for the valley was 72 packed boxes. In addition to the 100 men who pack, there are 8 who sort and pack. This is slower work when done by the piece. The pay is from $0.01 to $0.02 more per box than for merely packing. The seven orchardists in North Yakima who sort and pack 59 boxes in 10 hours, at the rate of 6 cents per packed box, give a fair average for the valley.

The diagonal pack is used (see fig. 13) and apples are sized by the packer, unless a mechanical sizer is used, in which case the rate paid per box is less, usually $0.03 to $0.04.

The packing cost per box on 100 farms studied was $0.05, or $21.68 per acre.

NAILING AND WAITING.

Many of the orchardists in both regions employ one man to nail the packed boxes and wait on the packers or sorters. The cost of nailing and waiting was $0.0132 per box for the North Yakima ranches and $0.0105 for those of Zillah, or an average of $0.0119 per box for both districts, 64 records being considered.

Other orchardists employ a man to do nothing but nail and stamp the boxes. It was found that a nailer when doing no other labor would nail 275 boxes per day on the North Yakima ranches and 281 on the Zillah ranches, or 278 when both districts were considered, while 210 boxes is the average day's work for nailing and waiting. Eleven of the men employed waiters who did nothing but wait on the packers and sorters, each handling about 284 boxes per day.

FOREMAN.

In most instances, on account of the small size of the orchards in these regions, it is not found necessary to employ a foreman. On the ranches studied there were but 6 men in the North Yakima district and 17 in the Zillah district who employed foremen in the packing houses. In most other cases the owner himself acted as foreman, at the same time doing some other labor in the packing house, usually nailing. On the ranches studied, where a foreman was employed the foreman cost per box was $0.0096, or practically $0.01 per box.

OTHER PACKING-HOUSE LABOR.

The other packing-house labor, which includes truckers, or men employed about the packing house to handle the fruit in some way other than those already mentioned, amounts to $0.0185 per box for the 23 men who employ other packing-house labor, or, if this is prorated over all records, $0.0035 per box.

ALL PACKING-HOUSE LABOR COSTS.

The total of all packing-house labor for the 108 men who did their own sorting and packing was $0.1039 per box, while in the case of the 12 men who hauled to an association warehouse and had the fruit packed it was $0.1209 per box, or for the total 120 records, $45.55 per acre, and $0.1054 per box, or 30.57 per cent of the total net maintanance and handling cost.

CULL APPLES.

Cull or cider apples which have been gathered from the ground or culled in the packing shed (see fig. 14) are often hauled to a cider mill in the vicinity of North Yakima. In the Zillah district there was no by-product plant at the time this study was made. A few of the growers hauled their cull apples in boxes to the town of Zillah and

shipped them to some town in which such a plant was located. The load is usually from 1 to 1½ tons.

One cider mill located in the vicinity of North Yakima might be termed a cooperative factory. A number of growers in the vicinity of North Yakima have put $100 each into this enterprise, and have the privilege of selling all their cull apples to the factory. If the mill is not kept busy by the apples of these stockholders, growers outside of the company have the privilege of delivering their cull apples at the same price received by the stockholders.

It is not the general practice of the growers of the valley, however, to pick up the apples in the orchard or sell their cull apples to a by-

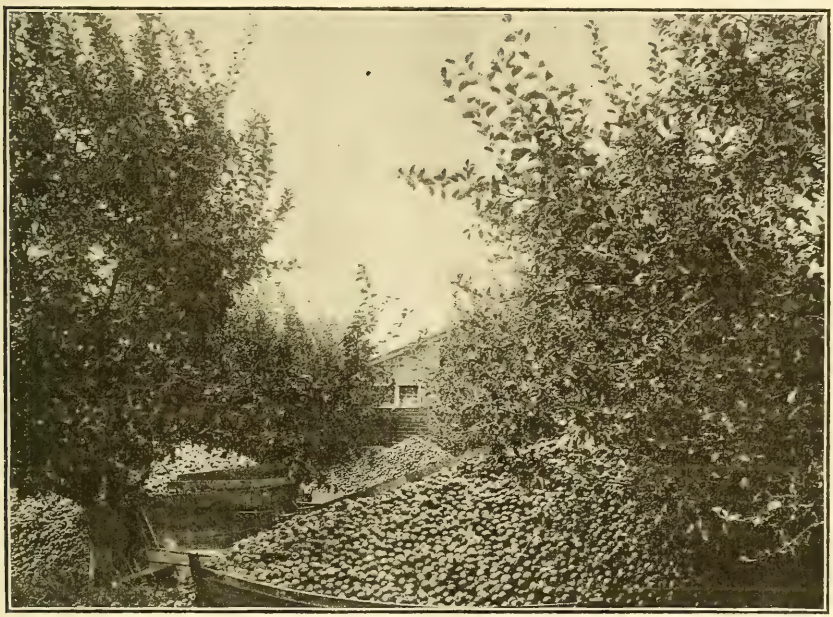


FIG. 14.—Culls outside of a large packing house. These culls are frequently a total waste. Sometimes they are made into cider or vinegar.

product plant. At the time of this investigation many of the growers on the farms studied did not believe the labor expended would be warranted by the price which they received for their cider apples. In many instances apples are picked up and used for live-stock feed or often the live-stock is pastured in the orchard for a time. Various estimates on the value of cull apples for feed were made by the orchardists under consideration. In each instance the orchard has been given the estimated credit for the feed value as given by the individual orchardist.

The usual price paid by the cider mill for cull apples during the past few years has been $4.50 per ton. The average net credit of the 57 orchardists who handled their cull apples was $3.68 per acre. Consid-

ering all records of the valley, the prorate credit was $2.25 per acre, or $0.0052 per box.

HAULING PACKED BOXES.

Boxes usually are hauled to the local association or station as soon as possible after the fruit is packed. The majority of growers use a wagon or truck with a crew of one man and two horses for hauling. Six growers used a crew of one man and one horse, one a crew of two men and two horses, and one a crew of three men and two horses. Nine orchardists in the North Yakima district hired their hauling done at a cost of from $0.015 to $0.025 per box, varying with the distance from the station. Seventy-seven per cent of the men in the North Yakima district and 96 per cent in the Zillah district used a crew of one man and two horses for hauling packed boxes to the station. Table XLI gives the comparative cost of hauling with a crew of one man and two horses in each district. The load varies from 50 to 120 boxes. For the entire valley the average cost for hauling packed boxes to the station with a crew of one man and two horses was $0.0150 per packed box, or $0.0085 per box per mile.

Considering the 120 records taken in the valley, regardless of whether the apples were hauled by the owners or by contract to a station or an association, the cost was $0.0165 per box, or $0.0089 per box per mile. The average distance hauled was 1.85 miles and the average load 81 boxes. (See Table XLII.)

TABLE XLI.—*Time and cost for hauling packed boxes to the station where a crew of one man and two horses is used.*

District.	Number of records.	Per acre.			Cost per box.	Average distance hauled.	Cost per box per mile.	Average load.	Yield per acre.
		Man-hours.	Horse-hours.	Cost.					
North Yakima	42	15.41	30.82	$8.47	$0.0169	2.49	$0.0068	96	501
Zillah	54	9.49	18.98	5.22	.0131	1.18	.0111	86	398
North Yakima and Zillah	96	12.08	24.16	6.64	.0150	1.75	.0085	90	443

The cost of all hauling, including the hauling of the shooks to the ranch, the orchard hauling, hauling full boxes to a central packing house, and hauling the packed box to the station, was 4.91 per cent of the total net cost of production on the ranches studied in the North Yakima district, and 5.37 per cent on those studied in the Zillah district. The total cost of all hauling for the records considered in the valley was 5.10 per cent of the total net cost of production, or $0.0408 per packed box.

TABLE XLII.—*Cost of all hauling on 120 farms studied.*

Operation.	Number of records.	Yield.	Load.	Miles.	Cost per acre.	Cost per packed box.	Cost per box per mile.
Hauling shooks	120	432	462	1.81	$1.66	$0.0038	$0.0021
Hauling boxes to and from orchard [1]	120	432	54	.....	8.84	.0205	.....
Hauling packed boxes to station (108) / Hauling loose boxes to association (12)	120	432	81	1.85	7.12	.0165	.0089

[1] Twelve orchardists hauled empty boxes to the orchard, but hauled their full boxes to a central packing shed.

TOTAL HANDLING COST.

The total net handling cost of the North Yakima district (64 orchards considered) was $89.26 per acre, or $0.1932 per box, while in the Zillah district (56 orchards considered) the acre cost was $86.12, or $0.2164 per box. The labor cost, with no credit for culls, was $0.0232 more per box in the Zillah district.

Considering all orchards studied, there appears to be little difference in the total net handling costs per box between the orchards under clean-cultural and those under mulch-crop management. On the former it is 56.97 per cent, the latter 63.12 per cent of the total net labor cost.

The total net handling cost for the 120 orchards studied was $87.79 per acre, or $0.2032 per box. This cost is 58.92 per cent of the total net labor, or 25.40 per cent of the total net cost of production.

TOTAL LABOR COST.

When the total labor cost for the 120 farms studied in the Yakima Valley is considered, there is found to be a net labor cost per acre of $149.01, or $0.3449 per box, after credit has been allowed for hay or pasture, wood for fuel, and all fruit not packed in boxes. This total credit amounts to $0.0190 per box. The net maintenance cost amounts to $0.1417 per box, or 41.09 per cent of the total net labor cost, while the net labor cost for handling amounts to $0.2032 per box, or 58.92 per cent of the total net labor cost. As will be seen from Table XLIII, the total net handling cost per box is practically the same under both the clean-cultural and the mulch-crop system, but the net labor cost per box for maintenance labor is much less in the case of the mulch-crop system. There is a net maintenance cost of $70.03 per acre in the case of the 75 clean-cultural orchards and $46.49 in the case of the mulch-crop orchards. If no credit is given the mulch-crop orchards, there is still a difference of $9.35 per acre in their favor. The cost per box, if no credit is given, is practically the same for the two systems, as the yield is 54 boxes per acre greater in the case of the clean-cultural orchards.

TABLE XLIII.—*Summary of all labor costs for Yakima Valley (120 records).*

Items.	Clean-cultural management (75 records; 452 boxes).				Mulch-crop management (45 records; 398 boxes).				Combined management (120 records; 432 boxes).			
	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.
	Per acre.	Per box.			Per acre.	Per box.			Per acre.	Per box.		
Manuring	$4.00	$0.0088	2.46	1.10	$3.46	$0.0087	2.74	1.09	$3.80	$0.0088	2.55	1.10
Pruning	13.42	.0297	8.24	3.69	12.66	.0318	10.04	4.01	13.14	.0304	8.82	3.80
Disposal of brush	4.59	.0102	2.82	1.26	4.53	.0114	3.59	1.43	4.57	.0106	3.06	1.32
Plowing	1.50	.0033	.92	.41	.65	.0016	.52	.20	1.18	.0027	.79	.34
Other cultivating	11.26	.0249	6.92	3.10	3.72	.0093	2.95	1.18	8.43	.0195	5.66	2.44
Irrigating	4.63	.0102	2.84	1.27	3.97	.0100	3.15	1.26	4.38	.0102	2.94	1.27
Thinning	13.08	.0289	8.04	3.60	11.13	.0280	8.83	3.52	12.35	.0286	8.29	3.57
Propping	1.67	.0037	1.03	.46	1.40	.0035	1.11	.44	1.57	.0036	1.05	.45
Miscellaneous	3.16	.0070	1.94	.87	1.88	.0047	1.49	.60	2.68	.0062	1.80	.78
Lime-sulphur spray	2.78	.0062	1.71	.77	2.77	.0070	2.20	.88	2.78	.0065	1.86	.81
Lead-arsenate spray	10.60	.0235	6.51	2.92	9.41	.0236	7.47	2.98	10.16	.0235	6.82	2.94
Sowing mulch crop					.03	.0001	.02	.01	.01		.01	
Harvesting mulch crop					5.73	.0144	4.55	1.81	2.15	.0050	1.44	.62
Total maintenance cost	70.69	.1564	43.43	19.45	61.34	.1541	48.66	19.41	67.20	.1556	45.09	19.44
Hay or pasture credit					14.26	.0358	11.31	4.51	5.35	.0123	3.59	1.55
Wood credit	.66	.0015	.40	.18	.59	.0015	.47	.19	.63	.0015	.42	.18
Total credit	.66	.0015	.40	.18	14.85	.0373	11.78	4.70	5.98	.0138	4.01	1.73
Total net maintenance cost	70.03	.1549	43.03	19.27	46.49	.1168	36.88	14.71	61.22	.1417	41.08	17.71
Hauling shooks	1.72	.0038	1.05	.47	1.55	.0039	1.23	.49	1.66	.0038	1.12	.48
Hauling boxes to and from orchard	9.65	.0214	5.93	2.66	7.49	.0188	5.94	2.37	8.84	.0205	5.93	2.56
Picking	27.99	.0620	17.20	7.70	23.68	.0595	18.78	7.49	26.38	.0611	17.70	7.63
Packing-house labor	47.65	.1054	29.28	13.11	42.04	.1056	33.35	13.31	45.55	.1054	30.57	13.18
Hauling to station or association	7.20	.0159	4.42	1.98	6.98	.0176	5.54	2.21	7.12	.0165	4.78	2.06
Picking up and hauling culls	.55	.0012	.34	.15	.41	.0010	.33	.13	.49	.0011	.33	.14
Total handling cost	94.76	.2097	58.22	26.07	82.15	.2064	65.17	26.00	90.04	.2084	60.43	26.05
Cull credit	2.04	.0045	1.25	.56	2.59	.0065	2.05	.82	2.25	.0052	1.51	.65
Total net handling cost	92.72	.2052	56.97	25.51	79.56	.1999	63.12	25.18	87.79	.2032	58.92	25.40
Total net labor cost	162.75	.3601	100.00	44.78	126.05	.3167	100.00	39.89	149.01	.3449	100.00	43.11

TABLE XLIV.—*Summary of all labor costs for North Yakima district (64 records).*

Items.	Clean-cultural management (43 records; 475 boxes).				Mulch-crop management (21 records; 434 boxes).				Combined management (64 records; 462 boxes).			
	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.
	Per acre.	Per box.			Per acre.	Per box.			Per acre.	Per box.		
Manuring	$3.16	$0.0067	1.99	0.80	$3.28	$0.0075	2.58	0.87	$3.20	$0.0069	2.15	0.82
Pruning	14.04	.0295	8.83	3.55	13.60	.0313	10.71	3.62	13.90	.0301	9.36	3.57
Disposal of brush	4.51	.0095	2.84	1.14	4.30	.0099	3.38	1.14	4.44	.0096	2.99	1.14
Plowing	1.62	.0034	1.02	.41	.86	.0020	.68	.23	1.37	.0031	.92	.35
Other cultivating	12.26	.0258	7.70	3.09	3.82	.0088	3.01	1.02	9.49	.0205	6.39	2.44
Irrigating	5.08	.0107	3.19	1.28	4.43	.0102	3.49	1.18	4.86	.0105	3.27	1.25
Thinning	9.34	.0197	5.87	2.36	8.13	.0187	6.40	2.16	8.94	.0194	6.02	2.29
Propping	2.02	.0043	1.27	.51	1.81	.0042	1.43	.48	1.95	.0042	1.31	.50
Miscellaneous	3.06	.0064	1.92	.77	1.85	.0043	1.46	.49	2.67	.0058	1.80	.69
Lime-sulphur spray	2.66	.0056	1.67	.67	2.63	.0061	2.07	.70	2.65	.0057	1.78	.68
Lead-arsenate spray	8.94	.0188	5.62	2.26	7.95	.0183	6.26	2.11	8.61	.0186	5.80	2.21
Sowing mulch crop					.03	.0001	.02	.01	.01		.01	
Harvesting mulch crop					8.11	.0187	6.39	2.16	2.66	.0058	1.79	.68
Total maintenance cost	66.69	.1404	41.92	16.84	60.80	.1401	47.88	16.17	64.75	.1402	43.59	16.62
Hay or pasture credit					16.58	.0382	13.06	4.41	5.44	.0118	3.66	1.40
Wood credit	.02		.01	.01					.01		.01	
Total credit	.02		.01	.01	16.58	.0382	13.06	4.41	5.45	.0118	3.67	1.40
Total net maintenance cost	66.67	.1404	41.91	16.83	44.22	.1019	34.82	11.76	59.30	.1284	39.92	15.22
Hauling shooks	2.10	.0044	1.32	.53	1.85	.0042	1.46	.49	2.02	.0044	1.36	.52
Hauling boxes to and from orchard	8.96	.0189	5.63	2.26	7.11	.0164	5.60	1.89	8.35	.0181	5.62	2.14
Picking	27.74	.0584	17.44	7.00	24.44	.0563	19.24	6.50	26.66	.0577	17.94	6.84
Packing-house labor	46.43	.0977	29.19	11.72	43.48	.1002	34.24	11.56	45.47	.0984	30.61	11.67
Hauling to station or association	8.86	.0186	5.57	2.24	8.60	.0198	6.77	2.29	8.78	.0190	5.91	2.25
Picking up and hauling culls	.80	.0017	.50	.20	.80	.0019	.63	.21	.80	.0017	.54	.21
Total handling cost	94.89	.1997	59.65	23.95	86.28	.1988	67.94	22.94	92.08	.1993	61.98	23.63
Cull credit	2.48	.0052	1.56	.62	3.51	.0081	2.76	.93	2.82	.0061	1.90	.72
Total net handling cost	92.41	.1945	58.09	23.33	82.77	.1907	65.18	22.01	89.26	.1932	60.08	22.91
Total net labor cost	159.08	.3349	100.00	40.16	126.99	.2926	100.00	33.77	148.56	.3216	100.00	38.13

TABLE XLV.—*Summary of all labor costs for the Zillah district (56 records).*

Items.	Clean-cultural management (32 records; 421 boxes).				Mulch-crop management (24 records; 367 boxes).				Combined management (56 records; 398 boxes).			
	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.	Cost.		Per cent of total net labor cost.	Per cent of total net cost of production.
	Per acre.	Per box.			Per acre.	Per box.			Per acre.	Per box.		
Manuring	$5.13	$0.0122	3.06	1.61	$3.63	$0.0099	2.90	1.38	$4.48	$0.0113	3.00	1.52
Pruning	12.59	.0299	7.51	3.94	11.85	.0323	9.46	4.50	12.27	.0308	8.21	4.15
Disposal of brush	4.70	.0112	2.80	1.47	4.73	.0129	3.78	1.80	4.71	.0119	3.15	1.59
Plowing	1.35	.0032	.80	.42	.46	.0013	.37	.17	.97	.0024	.65	.33
Other cultivating	9.92	.0236	5.92	3.10	3.63	.0099	2.90	1.38	7.23	.0182	4.83	2.45
Irrigating	4.02	.0095	2.40	1.26	3.57	.0097	2.85	1.36	3.83	.0096	2.56	1.30
Thinning	18.11	.0430	10.80	5.67	13.76	.0375	10.99	5.22	16.25	.0408	10.87	5.50
Propping	1.20	.0029	.72	.38	1.04	.0028	.83	.39	1.13	.0028	.76	.38
Miscellaneous	3.29	.0078	1.96	1.03	1.90	.0052	1.52	.72	2.70	.0068	1.80	.91
Lime-sulphur spray	2.94	.0070	1.75	.92	2.90	.0079	2.31	1.10	2.92	.0073	1.95	.99
Lead-arsenate spray	12.85	.0305	7.66	4.02	10.69	.0291	8.53	4.06	11.92	.0300	7.97	4.03
Sowing mulch crop					.03	.0001	.02	.01	.01		.01	
Harvesting mulch crop					3.64	.0099	2.91	1.38	1.56	.0039	1.04	.53
Total maintenance cost	76.10	.1808	45.38	23.82	61.83	.1685	49.37	23.47	69.98	.1758	46.80	23.68
Hay or pasture credit					12.23	.0334	9.76	4.64	5.24	.0131	3.50	1.77
Wood credit	1.52	.0036	.91	.48	1.11	.0030	.89	.42	1.34	.0034	.90	.45
Total credit	1.52	.0036	.91	.48	13.34	.0364	10.65	5.06	6.58	.0165	4.40	2.22
Total net maintenance cost	74.58	.1772	44.47	23.34	48.49	.1321	38.72	18.41	63.40	.1593	42.40	21.46
Hauling shooks	1.22	.0029	.73	.38	1.28	.0035	1.02	.49	1.25	.0031	.84	.42
Hauling boxes to and from orchard	10.57	.0251	6.30	3.31	7.84	.0214	6.26	2.98	9.40	.0236	6.29	3.18
Picking	28.33	.0672	16.89	8.87	23.01	.0627	18.37	8.73	26.05	.0655	17.42	8.82
Packing-house labor	49.30	.1171	29.39	15.43	40.77	.1111	32.55	15.47	45.64	.1147	30.52	15.44
Hauling to station	4.97	.0118	2.96	1.56	5.55	.0151	4.43	2.11	5.22	.0131	3.49	1.77
Picking up and hauling culls	.20	.0005	.12	.06	.09	.0002	.07	.03	.15	.0004	.10	.05
Total handling cost	94.59	.2246	56.39	29.61	78.54	.2140	62.70	29.81	87.71	.2204	58.66	29.68
Cull credit	1.45	.0034	.86	.45	1.78	.0048	1.42	.68	1.59	.0040	1.06	.54
Total net handling cost	93.14	.2212	55.53	29.16	76.76	.2092	61.28	29.13	86.12	.2164	57.60	29.14
Total net labor cost	167.72	.3984	100.00	52.50	125.25	.3413	100.00	47.54	149.52	.3757	100.00	50.60

Tables XLIV and XLV give the labor costs for North Yakima and Zillah separately. As will be seen, the net cost per acre for all labor for North Yakima is $148.56, or $0.3216 per box, making 38.13 per cent of the total of all net costs, and in the case of Zillah $149.52 per acre, or $0.3757 per box, making 50.60 per cent of the total of all net costs. The net labor costs for Zillah constitute a much greater proportion of the total annual net cost than do the net labor costs of the North Yakima district.

EXPENSES OTHER THAN LABOR.

The expenses other than labor consist of material and fixed costs, The material costs include manure, all spray materials, seed, gasoline, oil, made-up boxes, paper, nails, etc. The fixed costs include interest on apple orchard, the apple-building charge, equipment, depreciation and upkeep, hired equipment, land taxes, water rent, and insurance.

The material costs for the North Yakima ranches made up 21.59 per cent of the total net annual cost. The fixed costs made up 40.28 per cent of the total net annual cost. Thus the material and fixed costs for North Yakima made up 61.87 per cent of the total net annual cost. (See Table XLVI.)

The material costs for the Zillah ranches made up 27.62 per cent of the total net annual cost, while the fixed costs made up 21.78 per cent of the total net annual cost. Material and fixed expenses made up 49.40 per cent of the total net annual cost. (See Table XLVII.)

In the case of all records for the Yakima Valley, including the North Yakima and Zillah districts, the material cost made up 42.17 per cent of the expense other than labor, while the fixed cost made up 57.83 per cent. Together they made up 56.89 per cent of the total annual net cost of production. (See Table XLVIII.)

TABLE XLVI.—*Summary of material and fixed costs for North Yakima district (64 records).*

Material and fixed costs.	Clean-cultural management (43 records; 475 boxes).				Mulch-crop management (21 records; 434 boxes).				Combined management (64 records; 462 boxes).			
	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.
	Per acre.	Per box.			Per acre.	Per box.			Per acre.	Per box.		
Manure	$6.03	$0.0127	2.55	1.52	$5.07	$0.0117	2.03	1.35	$5.72	$0.0124	2.37	1.47
Lime and sulphur	5.66	.0119	2.39	1.43	6.18	.0142	2.48	1.64	5.83	.0126	2.42	1.50
Lead arsenate (first spray)	1.43	.0030	.60	.36	1.66	.0038	.67	.44	1.50	.0032	.62	.38
Other spray material	3.16	.0067	1.33	.80	3.33	.0077	1.34	.89	3.22	.0070	1.34	.83
Seed					.43	.0010	.17	.11	.14	.0003	.06	.03
Gasoline and oil	.63	.0013	.27	.16	.52	.0012	.21	.14	.59	.0013	.24	.15
Made-up box	69.02	.1453	29.11	17.42	63.06	.1453	25.32	16.77	67.13	.1453	27.85	17.23
Total material cost	85.93	.1809	36.25	21.69	80.25	.1849	32.22	21.34	84.13	.1821	34.90	21.59
Interest	117.58	.2475	49.59	29.68	132.57	.3055	53.23	35.25	122.50	.2652	50.81	31.44
Apple-building charge	4.75	.0100	2.00	1.20	4.34	.0100	1.74	1.15	4.62	.0100	1.92	1.18
Equipment charge	8.72	.0184	3.68	2.20	9.78	.0225	3.93	2.60	9.07	.0196	3.76	2.33
Sprayer hire	2.01	.0042	.85	.51	1.79	.0041	.72	.48	1.94	.0042	.80	.50
Taxes	14.39	.0303	6.07	3.63	15.04	.0347	6.04	4.00	14.60	.0316	6.06	3.75
Insurance	1.04	.0022	.44	.26	1.27	.0029	.51	.34	1.12	.0024	.46	.29
Water rent	2.66	.0056	1.12	.67	4.01	.0092	1.61	1.07	3.10	.0067	1.29	.79
Total fixed cost	151.15	.3182	63.75	38.15	168.80	.3889	67.78	44.89	156.95	.3397	65.10	40.28
Total material and fixed costs	237.08	.4991	100.00	59.84	249.05	.5738	100.00	66.23	241.08	.5218	100.00	61.87

TABLE XLVII.—*Summary of material and fixed costs for Zillah district (56 records).*

Material and fixed costs.	Clean-cultural management (32 records; 421 boxes).				Mulch-crop management (24 records; 367 boxes).				Combined management (56 records; 398 boxes).			
	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.
	Per acre.	Per box.			Per acre.	Per box.			Per acre.	Per box.		
Manure	$10.21	$0.0243	6.73	3.20	$6.17	$0.0168	4.46	2.34	$8.48	$0.0213	5.81	2.87
Lime and sulphur	6.40	.0152	4.22	2.00	6.09	.0166	4.41	2.31	6.27	.0157	4.30	2.12
Lead arsenate (first spray)	2.01	.0048	1.32	.63	1.94	.0053	1.40	.74	1.98	.0050	1.36	.67
Other spray material	6.29	.0149	4.15	1.97	5.30	.0144	3.84	2.01	5.87	.0147	4.02	1.99
Seed					.24	.0007	.17	.09	.10	.0003	.07	.03
Gasoline and oil	1.14	.0027	.75	.36	1.04	.0028	.75	.40	1.10	.0028	.75	.37
Made-up box	61.17	.1453	40.32	19.15	53.33	.1453	38.58	20.24	57.83	.1453	39.61	19.57
Total material cost	87.22	.2072	57.49	27.31	74.11	.2019	53.61	28.13	81.63	.2051	55.92	27.62
Interest	45.15	.1073	29.76	14.13	45.00	.1226	32.56	17.08	45.09	.1133	30.89	15.26
Apple-building charge	4.21	.0100	2.77	1.32	3.67	.0100	2.66	1.39	3.98	.0100	2.73	1.35
Equipment charge	6.41	.0152	4.23	2.01	6.68	.0182	4.83	2.53	6.52	.0164	4.46	2.21
Sprayer hire	.85	.0020	.56	.27	.35	.0010	.25	.13	.64	.0016	.44	.22
Taxes	6.72	.0160	4.43	2.10	7.00	.0190	5.06	2.66	6.84	.0172	4.68	2.31
Insurance	.35	.0008	.23	.11	.50	.0014	.36	.19	.42	.0011	.29	.14
Water rent	.81	.0019	.53	.25	.92	.0025	.67	.35	.86	.0021	.59	.29
Total fixed cost	64.50	.1532	42.51	20.19	64.12	.1747	46.39	24.33	64.35	.1617	44.08	21.78
Total material and fixed costs	151.72	.3604	100.00	47.50	138.23	.3766	100.00	52.46	145.98	.3668	100.00	49.40

TABLE XLVIII.—*Summary of material and fixed costs for Yakima Valley (120 records).*

Material and fixed costs.	Clean-cultural management (75 records; 452 boxes).				Mulch-crop management (45 records; 398 boxes).				Combined management (120 records; 432 boxes).			
	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.	Cost.		Per cent of total material and fixed cost.	Per cent of total net cost of production.
	Per acre.	Per box.			Per acre.	Per box.			Per acre.	Per box.		
Manure	$7.82	$0.0173	3.90	2.15	$5.66	$0.0142	2.98	1.79	$7.01	$0.0162	3.56	2.03
Lime and sulphur	5.97	.0132	2.97	1.65	6.13	.0154	3.23	1.94	6.03	.0140	3.07	1.74
Lead arsenate (first spray)	1.68	.0037	.84	.46	1.81	.0046	.95	.57	1.73	.0040	.88	.50
Other spray material	4.50	.0100	2.24	1.24	4.38	0110	2.31	1.39	4.45	.0103	2.26	1.29
Seed					.33	0008	.17	.10	.12	.0003	.06	.03
Gasoline and oil	.85	.0019	.42	.23	.80	.0020	.42	.25	.83	.0019	.42	.24
Made-up box	65.68	.1453	32.73	18.07	57.83	.1453	30.45	18.31	62.77	.1453	31.92	18.16
Total material cost	86.50	.1914	43.10	23.80	76.94	.1933	40.51	24.35	82.94	.1920	42.17	23.99
Interest	86.68	.1918	43.19	23.85	85.87	.2158	45.22	27.18	86.37	.1999	43.91	24.98
Apple-building charge	4.52	.0100	2.25	1.24	3.98	.0100	2.10	1.26	4.32	.0100	2.20	1.25
Equipment charge	7.73	.0171	3.85	2.13	8.13	.0204	4.28	2.58	7.88	.0183	4.01	2.28
Sprayer hire	1.52	.0034	.76	.42	1.02	.0026	.54	.32	1.33	.0031	.68	.38
Taxes	11.12	.0246	5.54	3.06	10.75	.0270	5.66	3.40	10.98	.0254	5.58	3.18
Insurance	.75	.0016	.38	.21	.86	.0022	.45	.27	.79	.0018	.40	.23
Water rent	1.87	.0041	.93	.51	2.36	0059	1.24	.75	2.06	.0048	1.05	.60
Total fixed cost	114.19	.2526	56.90	31.42	112.97	.2839	59.49	35.76	113.73	.2633	57.83	32.90
Total material and fixed costs	200.69	.4440	100.00	55.22	189.91	.4772	100.00	60.11	196.67	.4553	100.00	56.89

MATERIAL COSTS.

The first item of material is the manure. As will be seen, the clean-cultural orchards applied the more manure. This is as would be expected, as the mulch-crop adds humus to the soil and manure usually is not needed so badly on those orchards as on the others. On the clean-cultural orchards 4 tons were applied per acre in North Yakima and 6.8 tons in Zillah, or 5.21 tons for the 75 clean-cultural orchards studied in the entire valley. On the mulch-crop orchards 3.38 tons were applied in North Yakima and 4.11 tons in Zillah, making an average of 3.77 tons per acre for the 45 mulch-crop orchards studied in the valley. If the mulch-crop and clean-cultural orchards are combined (120 records), there is found to be an average of 4.67 tons applied per acre. This manure is charged at the rate of $1.50 per ton for the entire district. There was, then, a cost of $7.01 per acre for manure for the entire Yakima Valley, or $0.0162 per box. The cost for the clean-cultural orchards was $7.82 and for the mulch crop $5.66 per acre.

The spray material is one of the principal items of material costs. This includes the lime-sulphur, arsenate of lead, and any other spray materials which are used. For all records, lime-sulphur, figured at the rate of $0.15 per gallon, cost $6.03 per acre, while other spray materials amounted to $6.18 per acre; thus all spray materials amounted to $12.21 per acre, or $0.0283 per box, making up 6.21 per cent of the material and fixed costs. The spray-material cost for the districts of North Yakima and Zillah is shown in Tables XLVI and XLVII.

Arsenate of lead paste had been charged at the rate of $0.09 per pound. Another item of material cost, amounting to very little in the total and appearing only on the mulch-crop orchards, is the seed used for mulch-crop. Usually this is clover, alfalfa, or sweet-clover seed, and is sown only occasionally. The annual charge for this amounts to but $0.33 per acre for the 45 mulch-crop records in the valley, or when distributed over the 120 orchards, including the clean-culture records, it amounts to but $0.12 per acre.

The gasoline and oil charge is used here in addition to the regular upkeep of the spray rig. This gasoline charge for all records in the valley amounted to $0.83 per acre, or $0.0019 per box. It is arrived at by allowing one pint per horsepower for each hour that the spray rig is used in the bearing orchard.

The cost of made-up box is $0.1453. This includes the shook, paper, nails, and the work of making it up, divided as follows:

Shook	$0.1050
Making up	.0065
Nails	.0056
Paper, including lining and wrapping	.0282
Total	$0.1453

The made-up box cost is 31.92 per cent of the material and fixed costs.

The total of all material and fixed costs is $82.94 per acre, or $0.1920 per box. For the 75 clean-cultural records it is $86.50 per acre, or $0.1914 per box, while for the mulch-crop it is $76.94 per acre, or $0.1933 per box. It is thus seen that the material cost per box varies but $0.0019 between the clean-cultural and mulch-crop systems of management.

FIXED COSTS.

The largest single item of fixed costs is the interest on apple-orchard investment. This charge is often a determining factor in the apple business. In the case of Zillah this cost amounts to $45.09 per acre, or $0.1133 per box, for the ranches studied, while in the case of North Yakima it amounts to $122.50 per acre, or $0.2652 per box. This difference is due to the difference in the bearing apple land valuation, which in Zillah is $563.57 per acre, while in North Yakima it is $1,513.25. For Zillah this interest charge makes 15.26 per cent of the total annual net cost of production, while in North Yakima it makes 31.44 per cent. Tables XLVI and XLVII show the difference in this cost between the mulch-crop and clean-cultural orchards. In Table XLVIII, where North Yakima and Zillah records are shown combined, there is found to be an acre cost of $86.37 or practically $0.20 per box for this interest charge, thus making up 24.98 per cent of the total annual net cost of production. Interest in this region is figured at the rate of 8 per cent.

Several growers have buildings devoted especially to apples, the charge for which appears in the "apple-building charge." Usually these are inexpensive packing houses or sheds. The investment varies greatly, and in many cases where expensive packing houses or barns are on the place they are used for other purposes when not needed in handling the apple crop. It is therefore difficult to arrive at a proper investment charge for the apple orchard for such buildings. Such data and annual costs for this item as were secured were found to amount to practically $0.01 per box per year. In order that this figure might be comparable, the arbitrary figure of $0.01 per box for apple-building charge is used for records for the entire valley. This charge amounts to $4.32 per acre.

In arriving at the equipment charge, the average investment in equipment is determined and the amount chargeable to the apple orchard is arrived at by finding the percentage value that the apple orchard represents of the total land and improvement investment. This percentage value is figured on the equipment. That is, if the apple orchard represents 50 per cent of the land and improvement investment, 50 per cent of the equipment is charged to the apple orchard.

The equipment charge for the Zillah ranches was $6.52 per acre, while for those of North Yakima it was $9.07. The relatively higher cost for North Yakima is attributable to the fact that the farms there are small, necessitating a comparatively heavy equipment per acre. A 25 per cent annual charge was used for equipment in this region. This charge is divided as follows: 11 per cent, depreciation; 8 per cent, interest; 5 per cent, upkeep; 1 per cent, taxes.

This equipment charge is naturally more or less an arbitrary figure. It is impossible to tell just how much equipment is used on the orchard and just what percentage should be the equipment charge; also the equipment of many growers depreciates much more rapidly than that of others. Available data from this and other western apple-growing regions indicate that there is an average charge of fully 25 per cent for the equipment found on the average apple farm.

In addition to the regular equipment charge, there is another charge of like nature, namely, the spray rig hire. In many orchards of the valley those growers who do not have a rig have to hire their spraying done. This cost, when prorated over all records, amounted to $1.94 per acre for the North Yakima ranches and $0.64 per acre for those of Zillah, the difference reflecting the fact that a greater proportion of growers in North Yakima hired their spraying done than in Zillah. This charge is included under fixed costs, as it merely goes to make up the lack of equipment charge on those orchards which do not have a spray rig. Thus, for the 120 records, there is a spray rig hire of $1.33 per acre, or $0.0031 per box. If this regular equipment charge and spray rig hire are added together, forming what might be termed a total equipment charge, there is found to be an acre cost for all records of $9.21, or $0.0214 per box.

The land tax rate, as in many other Northwestern districts, is very high as compared to Eastern farming districts. For the farms studied in the North Yakima district it was $14.60 per acre, or $0.0316 per box, while for the Zillah district it was $6.84 per acre or $0.0172 per box. The high tax rate for North Yakima is due largely to the locality, much of the fruit being located on Nob Hill, where land has a high valuation due to its residential advantages. The cost of all taxes amounts to $10.98 per acre, or $0.0254 per box.

The water tax or rent is much higher in North Yakima than in Zillah, since many of the Zillah orchards are on the Konowak ditch and have free water right. The water rent amounted to $3.10 per acre for the North Yakima farms and $0.86 per acre for Zillah. The water rent for the 120 orchards was $2.06, or nearly $0.005 per box. As will be seen from Tables XLVI, XLVII and XLVIII, the water rent was higher in all cases in the mulch-crop orchards. This is not due to the orchards being in mulch crop, but to the fact that they happened to be situated in the more expensive irrigation districts.

There is an annual fire insurance on farm buildings, of which the apple orchard bears a part. This charge amounts to very little—$1.12 per acre for North Yakima, $0.42 per acre for Zillah, and $0.79 per acre, or $0.0018 per box, for all records.

All fixed costs amounted to $156.95 per acre for North Yakima and $64.35 per acre for Zillah, the great difference being due almost entirely to the high land valuation in North Yakima. As will be seen in Tables XLVI, XLVII, and XLVIII, the difference in this total fixed cost does not vary greatly with the system of soil management. For the 120 orchards considered in the valley the fixed costs per acre were $113.73, or $0.2633 per box. The total material and fixed costs for all orchards amounted to $241.08 per acre, or $0.5218 per box, for North Yakima, and $145.98 per acre, or $0.3668 per box, for Zillah. In the former case they make up 61.87 per cent of the total annual net cost of production, while in the latter case they make up 49.40 per cent.

For the 120 orchards studied in the valley there was a cost of $196.67 for material and fixed costs or expenses other than labor, or $0.4553 per box. This made up 56.89 per cent of the total annual net cost of production. It is evident that the crop determines the material cost to a certain degree, especially as regards the cost of made-up boxes, which depends directly on the yield. In the case of the fixed costs, though size of crop has no influence on the acre cost, there is a great saving in cost per box as the yield increases. That is, the fixed cost for a yield of 200 boxes is no less per acre than in the case of a yield of 400 boxes, but is twice the amount per box in the former as compared with the latter.

TOTAL OF ALL COSTS.

When the total of all costs for the 120 farms studied in the Yakima Valley is considered, there is found to be an annual acre cost of $345.68 per acre, or $0.8002 per box. This is figured on an average annual yield of 432 boxes per acre. The two groups of costs which go to make this up are the total net labor cost and the total material and fixed cost, or costs other than labor. The net labor cost is $0.3449 per box, or 43.11 per cent of the total net cost of production, the net maintenance making up 17.71 per cent, and the net handling cost 25.40 per cent. Material and fixed costs were $0.4553 per box, or 56.89 per cent of the total net cost, 23.99 per cent being material cost and 32.90 per cent fixed cost. The greatest item of fixed cost is the interest on investment, which made up 43.91 per cent of the cost other than labor and 24.98 per cent of the total net annual cost.

If the 120 orchards are separated into groups according to soil management, 75 under the clean-cultural system and 45 under the mulch-crop system, there is found to be a cost of $0.8041 per box for

those under clean-cultural and $0.7939 per box for those under the mulch-crop system. Thus, in the case of these ranches, there appears to be little difference in the cost per box under the different systems. This is attributable to the yield being 54 boxes per acre higher in the case of the 75 orchards under the clean-cultural system than in the case of the 45 under the mulch-crop system. The net labor cost for the orchards studied under the clean-cultural system is $0.0434 more per box than those under the mulch-crop system. This difference is due in part to credit received from hay on orchards under mulch-crop management, and in part to the smaller cost of tillage in the mulched orchards. The material and fixed cost is more per box in the case of the mulch-crop orchards, as might be expected from the lower yield.

Table XLIX is a summary of all costs considered in the cost of producing apples on 120 farms in the Yakima Valley. For the 64 records in the North Yakima district there was a total net cost of $0.8434 per box, while for the 56 records in Zillah it was $0.7425 per box. The fixed cost for the North Yakima district was $156.95 per acre, or $0.3397 per box, or 40.28 per cent of the total of all net costs, while for Zillah the total fixed cost was $64.35 per acre, or $0.1617 per box, or 21.78 per cent of the total net cost. Thus the item of fixed costs is practically twice as great on the farms studied in the North Yakima region as on those about Zillah. This higher total net cost in the North Yakima district is due directly to the relatively higher land valuation. If interest on investment is not taken into account there is found to be an average annual net cost per acre of $259.31, or $0.6003 per box, for the 120 farms studied in the valley. In the case of North Yakima the net cost, minus interest, is $0.5782 per box, while in Zillah it is $0.6292 per box. In considering the correct total cost of production this interest should not be deducted, but included, as in the first part of the discussion. It is a legitimate charge necessary to present real cost. Often, however, the interest charge is not taken into consideration in presenting the cost of production, though it is one of the greatest factors bearing upon success or failure in the fruit industry. Counting interest on investment, the average annual net cost of production on these 120 farms representative of the Yakima Valley is $345.68 per acre, or $0.8002 per box. In Table L this total cost is subdivided to show the cost of the apples on the tree and the handling cost.

TABLE XLIX.—*Summary of all costs for Yakima Valley (120 records).*

District and character of cost.	Clean-cultural management (43 records; 475 boxes).			Mulch-crop management (21 records; 434 boxes).			Combined management (64 records; 462 boxes).		
	Cost.		Per cent of total net cost.	Cost.		Per cent of total net cost.	Cost.		Per cent of total net cost.
	Per acre.	Per box.		Per acre.	Per box.		Per acre.	Per box.	
North Yakima:									
Total net maintenance cost	$66.67	$0.1404	16.83	$44.22	$0.1019	11.76	$59.30	$0.1284	15.22
Total net handling cost	92.41	.1945	23.33	82.77	.1907	22.01	89.26	.1932	22.91
Total net labor cost	159.08	.3349	40.16	126.99	.2926	33.77	148.56	.3216	38.13
Total material cost	85.93	.1809	21.69	80.25	.1849	21.34	84.13	.1821	21.59
Total fixed cost	151.15	.3182	38.15	168.80	.3889	44.89	156.95	.3397	40.28
Total material and fixed costs	237.08	.4991	59.84	249.05	.5738	66.23	241.08	.5218	61.87
Total net cost of production	396.16	.8340	100.00	376.04	.8664	100.00	389.64	.8434	100.00
	(32 records; 421 boxes.)			(24 records; 367 boxes.)			(56 records; 398 boxes.)		
Zillah:									
Total net maintenance cost	$74.58	$0.1772	23.34	$48.49	$0.1321	18.41	$63.40	$0.1593	21.46
Total net handling cost	93.14	.2212	29.16	76.76	.2092	29.13	86.12	.2164	29.14
Total net labor cost	167.72	.3984	52.50	125.25	.3413	47.54	149.52	.3757	50.60
Total material cost	87.22	.2072	27.31	74.11	.2019	28.13	81.63	.2051	27.62
Total fixed cost	64.50	.1532	20.19	64.12	.1747	24.33	64.35	.1617	21.78
Total material and fixed costs	151.72	.3604	47.50	138.23	.3766	52.46	145.98	.3668	49.40
Total net cost of production	319.44	.7588	100.00	263.48	.7179	100.00	295.50	.7425	100.00
	(75 records; 452 boxes.)			(45 records; 398 boxes.)			(120 records; 432 boxes.)		
Yakima Valley:									
Total net maintenance cost	$70.03	$0.1549	19.27	$46.49	$0.1168	14.71	$61.22	$0.1417	17.71
Total net handling cost	92.72	.2052	25.51	79.56	.1999	25.18	87.79	.2032	25.40
Total net labor cost	162.75	.3601	44.78	126.05	.3167	39.89	149.01	.3449	43.11
Total material cost	86.50	.1914	23.80	76.94	.1933	24.35	82.94	.1920	23.99
Total fixed cost	114.19	.2526	31.42	112.97	.2839	35.76	113.73	.2633	32.90
Total material and fixed costs	200.69	.4440	55.22	189.91	.4772	60.11	196.67	.4553	56.89
Total net cost of production	363.44	.8041	100.00	315.96	.7939	100.00	345.68	.8002	100.00

TABLE L.—*Total cost of apples on the tree, handling cost, and the total cost per acre and per box.*

Character of cost.	North Yakima district (64 records; 462 boxes).		Zillah district (56 records; 398 boxes).		North Yakima and Zillah districts (120 records; 432 boxes).	
	Per acre.	Per box.	Per acre.	Per box.	Per acre.	Per box.
Net maintenance cost	$59.30	$0.1284	$63.40	$0.1593	$61.22	$0.1417
Material and fixed costs [1]	169.33	.3665	84.17	.2115	129.58	.3000
Net cost on the tree	228.63	.4949	147.57	.3708	190.80	.4417
Net handling cost	161.01	.3485	147.93	.3717	154.88	.3585
Total net cost	389.64	.8434	295.50	.7425	345.68	.8002

[1] In this table the cost of made-up box and the apple-building charge are included in "net handling cost."

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 615

Joint Contribution from the Office of Farm Management, W. J. SPILLMAN, Chief, and the Bureau of Animal Industry, A. D. MELVIN, Chief.

Washington, D. C. November 15, 1917

THE ECONOMICAL WINTER FEEDING OF BEEF COWS IN THE CORN BELT.

By J. S. Cotton, *Office of Farm Management, and* Edmund H. Thompson, *Scientific Assistant, Bureau of Animal Industry.*

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THE NEED FOR MORE ECONOMICAL FEEDING OF BREEDING COWS.

A great many farmers in the corn-belt States keep cows of the beef or the dual purpose type for the production of feeder calves. On the smaller farms, having twenty cows or less, the custom is to milk the cows and to sell milk products, usually cream. The calves from some of these farms are sold to other farmers, who make a practice of purchasing such animals and of feeding them out in carload lots. Some farmers, however, make a practice of finishing their own calves and enough more calves bought from their neighbors to enable them to fill out a carload. On the larger farms, twenty cows or more usually are kept only for the production of feeder calves, which usually are fed out on the same farm as baby beef, or as two-year-olds, or three-year-olds. On some of the farms of the above-described types calves are produced at a substantial profit, and on others, calves are produced at a heavy loss.

Although there are a number of factors that govern the profitableness of the calf-growing enterprise, an investigation carried on by the United States Department of Agriculture in the corn-belt States

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during the last three years show that losses on calves usually are due to excessive maintenance costs of the breeding cows.[1]

Much study has been devoted to selecting for dairy cows, and also for fattening cattle, rations that will give the best and most economical results. There seems, however, to be but little information on the best rations for beef-breeding cows, although the data at hand clearly indicate that these animals must be wintered at as low a cost as is consistent with their welfare. When a cow is kept only for the production of calves, she should be fed a ration that will enable her to produce and raise a good strong calf and still keep in good bodily condition. To feed in excess of this amount merely for the sake of having a fine appearing cow, as is frequently done, is a waste of feed. This waste increases the maintenance cost, often to the point of wiping out profits, for when the business is conducted on as close a margin as at present it is impossible to raise calves at a profit unless the strictest economy is practiced in feeding the cows.

BREEDING HERDS MUST GET MOST OF THEIR LIVING FROM FARM BY-PRODUCTS.

The information at hand shows that where cows are kept exclusively for the production of feeder animals there must be a sufficient area of pasture, most economically utilized, to support the animals for at least six months of the year. Not only must they get fully one-half of their living from cheap grazing but they must be so handled during the remainder of the year that the greater portion of their winter feed is made up of those unsalable rough feeds, such as stalks, stover, and straw, which are abundant on corn-belt farms. The data obtained also show that on corn-belt farms the size of the herds usually should be limited to the number that can be supported on such cheap feeds. In other words, with the prices prevailing during recent years, the breeding herds must be made to utilize the farm by-products and convert them into beef and manure, while the more valuable products are sold or are fed to fattening animals.

Every year there are large quantities of corn stover which are not utilized to their fullest extent. Every year also a vast quantity of straw is wasted by letting cattle run to the stack and trample under foot more straw than they eat. An excellent illustration of this is shown in figure 1, where straw piles for three successive years are shown. Most of the straw on this farm is allowed to rot in piles and is not even hauled out as manure. In some parts of the country large quantities of straw are destroyed by burning. Much of the

[1] This investigation is being conducted cooperatively by the Office of Farm Management and the Bureau of Animal Industry. The results of the first two years' work have been published in Report 111, Office of the Secretary, "Methods and Cost of Growing Beef Cattle in the Corn Belt States."

straw so wasted might be used to replace some of the more valuable feeds that beef cows receive. It is true that in many parts of the country in times past it has been better farm economy to allow these products to be destroyed rather than to try to use them. However, under present conditions, not only is it necessary that cattle should be handled in such a manner as to use as much of these by-products as possible, but also, if possible, the farm business should be arranged so that enough stock is kept to consume fully these cheap roughages.

These cheaper rough feeds can be utilized more fully than is customary and much less grain and hay need be fed to breeding herds. This is demonstrated by the results of the investigation upon which this bulletin is based. In this investigation approximately 1,000 farms were visited, and detailed information was obtained on the cost of maintaining the breeding herds on these farms as well as on

FIG. 1.—Here the straw is fed in the winter feed lot, where the cattle run to the stack and trample under foot the straw they do not eat. In this particular case the straw is not even saved for manure.

the cost of producing the feeder cattle. In addition to the cost accounting figures, a study also was made of the methods used in caring for the cattle. This study is based on records from 478 of these farms, upon which the breeding herds were kept solely for the production of calves to be fed out as baby beef, two-year-olds, or three-year-olds. On these farms the average cost of a calf at weaning time, figuring all expenses and deducting all credits, was $37. There was, however, a very wide range in the cost of these calves, depending somewhat on the locality in which the calves were raised and very largely on the methods followed in producing them. On some farms this cost was as low as $25 per calf, while on others it exceeded $50.

On the farms visited there was a very wide range both in the quantity and the kind of rations fed. Some farmers were feeding a ration that was hardly adequate, while others were giving their

cows more feed than they could possibly eat. Some were carrying their cows through the winter in fairly good condition at a very low cost, while others were using large quantities of expensive hay and grain, with a resultant heavy winter feed bill. Many of the latter could have greatly reduced the cost of their rations by a judicious substitution of cheaper feeds for some of the more expensive ones.

AVOID FEEDING EXCESSIVE RATIONS.

That the various rations, which differed widely in kinds of feeds used as well as in quantity given, might be made comparable, all the feeds for these 478 farms were reduced to the "feed unit" basis, in which 1 pound of corn is equivalent to one feed unit.[1] In this system 1 pound of alfalfa equals one-half feed unit, and 1 pound of cottonseed meal makes one and one-quarter feed units.

TABLE I.—*Effect of varying quantities of winter feed on the economic production of calves.*

Feed units per animal (165 days).	Number of farms.	Average number of units fed.	Cost of winter feed per cow.	Cost of keeping a cow one year.	Cost of calf at weaning time.
Under 1,750	131	1,550	$10.70	$29.00	$30.00
1,750 to 2,249	142	2,000	13.50	33.50	35.00
2,250 to 2,749	83	2,350	18.50	37.20	41.00
2,750 and over	122	3,200	21.00	39.60	43.00
All farms	478	2,280	15.50	34.50	37.00

On the basis of the average quantity of feed given to a cow, the records from these 478 farms were divided into four groups. That they might be comparable they also were standardized to a winter feeding period of 165 days, this being the average for all the farms. In the first group, 131 farms (see Table I), the cows were given an average of 1,550 feed units per head during the winter feeding period. The cows in the second group, 142 farms, received an average of 2,000 feed units, while those in the third group were fed an average of 2,350 feed units. In the fourth group, 122 farms, an average of 3,200 feed units per head was fed during the winter, this being double the amount fed to the cows in the first group. On 30 of the farms in the last group the cows were fed more than 4,300 feed units per head, or nearly three times as much as those in the first group.

This great variation in the quantity of feed given in the different groups was not due to any especial difference in the kinds of feeds, as the average ration in the four groups contained the same propor-

[1] See "Feeds and Feeding," 16th edition, Henry and Morrison, pp. 126–128.

tion each of cheap roughages, hay, fodder, silage, and grain. This being the case it is evident that if the farms in the first two groups, which comprise approximately two-thirds of all the farms, were feeding their cows enough, the rest were feeding their cows a great deal more than they needed. Much of this excess feed undoubtedly was trampled under foot and wasted.

The records in the first two groups were analyzed to determine whether the cows in these groups were receiving a ration that was adequate for the maintenance of a cow in calf. The analyses showed that although the rations on a few of the farms in the first group were hardly adequate, nevertheless the majority of the cows were getting enough feed to carry them through the winter in fair condition. It also showed that the cows in the second group were receiving ample feed; in some cases even more than was absolutely necessary.

The cows in the first group were wintered at an average cost for feed of $10.70 and those in the second at $13.50 per head.[1] The winter feed bill for the cows in the third and fourth groups was $18.50 and $21, respectively. Thus on nearly one-half of these farms the cost of wintering the cows could have been reduced materially, and many of the calves that were produced at a loss could have been grown at a profit. In fact, 800 of the calves produced on the farms in the first group were sold at weaning time for an average profit of $4.60 per head, while 700 from farms of the last group sold at the same time showed a loss of $8.90 per head. As the number of calves sold at weaning time is hardly large enough to constitute a fair index, the average value of the remaining calves, inventoried when turned on pasture at an average age of 13 months, may be cited. The inventoried value of the calves in all four groups was approximately $38 per head. The 2,200 calves inventoried in the first group showed a loss of but $5 at that time, while the 1,600 inventoried in the last group showed an average loss of nearly $20 a head.[2]

An effort was made to determine whether the varying rations had any effect on the number of calves produced and on their quality. This study showed that the percentage of calves was approximately the same in each of the four groups.

[1] In determining the cost of the winter feed for the cow, the various feeds were, so far as possible, priced at their sale value on the farm—that is, the market value less cost of hauling. The price for fodder was based on the value of the corn it contained plus a charge for the cutting and the value of the stalks or stover. Silage was figured in much the same manner.

[2] The calves were inventoried when they were turned on pasture, May 1. As they still had to maintain all expenses of the breeding herd as well as an expensive winter feed bill, they were inventoried at relatively the most expensive point in their history. Had the calves been carried on pasture until the following November and then inventoried, those in the first group would have given a substantial profit, while the loss on the others would have been much less.

AVOID COSTLY RATIONS.

Not only were some of the farmers giving their cows too much feed, but many of the feeds used were altogether too high priced. The farms were again divided into four groups, the grouping based on the average daily feed cost per cow. The average daily feed cost per cow in each of these groups was as follows: 5.8 cents on 98 farms, 8.4 cents on 162 farms, 10.3 cents on 131 farms, and 13.7 cents on 87 farms. The average winter feed cost for the cows in the first group was $10. In spite of the fact that the cows in the fourth group were carried for a 10-day shorter winter feeding period, and were given nearly one-fifth less feed than those of the first group, they cost $12 a head more to winter, or $22. This great difference in the cost of wintering the cows in these two groups was due largely to the kinds of feed used. The farmers in the first group were carrying their cows through the winter on a ration 62 per cent of which was made up of cheap roughages, such as stalks, stover (cut corn from which the ears have been removed), oat and wheat straw, and some winter pasture. The remainder of the ration consisted of 30 per cent hay, 4 per cent fodder (cut corn containing the ears), and 2 per cent each of silage and grain. The cows in the fourth group, which were fed at a cost of 13.7 cents a head per day, were, on the other hand, receiving a ration that contained only 24 per cent cheap roughage as against 40 per cent hay, 12 per cent fodder, 14 per cent silage, and 10 per cent grain.

USE MORE CHEAP ROUGHAGE.

The figures cited above indicate that there is an opportunity for many of the corn-belt farmers to reduce considerably their winter feed bill by the greater utilization of the farm by-products, such as straw and corn stover. A study, therefore, was made to determine the effect of feeding varying proportions of these cheap roughages, the farms again being divided into groups. There were 14 farms (see Table II) on which no cheap roughages were fed. The average ration on these farms was composed of 54 per cent hay, 25 per cent fodder, 10 per cent silage, and 11 per cent grain. The daily cost of this ration was 11 cents. In the second group, 229 farms, the average quantity of cheap roughages fed was 24 per cent, these feeds replacing fodder and silage to a limited extent. Although the figures show a smaller percentage of hay and grain, as a matter of fact the farms in this group fed on the average one-tenth of a ton more hay and a little more grain than those of the first group, feeding altogether 2,250 feed units as against 1,950 for those in the first group. Because of the larger amount of feed given, this ration cost approxi-

mately the same as that for the first group, or 10.7 cents daily. On the 207 farms of the third group the cheap roughages replaced to a great extent the more expensive feeds. Although these farmers were the heaviest feeders, this ration cost per cow 2.5 cents a day less than that for the second group, and 2.8 cents less than that for the first group. This means a saving of $4 or more in the winter feed bill for each cow.

TABLE II.—*Relative percentage of different feeds where varying quantities of cheap roughage are fed and effect of these rations on cost of keeping a cow and of producing a calf.*

Relative quantity of cheap roughage.	Number of farms.	Total feed units.	Cheap roughage.	Hay.	Fodder[a] and silage.	Grain.	Daily feed cost per cow.	Winter feed cost per cow.	Cost of calf at weaning time.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Cents.*		
No cheap roughage	14	1,950	0	54	35	11	11.0	$18.00	$39.00
1 to 39 per cent	229	2,250	24	47	23	6	10.7	17.70	39.00
40 to 79 per cent	207	2,350	58	28	10	4	8.2	13.80	34.00
80 per cent and over	28	2,150	89	6	2	3	5.5	9.00	30.00

[a] By "corn fodder" is meant the entire plant cut and shocked. In many localities it is known as "shock corn."

The calf crop was practically the same in all three groups, 87.1 in the first and 85.5 each in the two others. The calves in the third group cost $34 at weaning time, as against approximately $39 for those in the first and the second group. Of the calves sold at this time, 1,150 in the third group show a profit of about 75 cents each; while 1,050 in the two other groups show a loss of approximately $4 per head. The calves in the first two groups were produced at a loss largely because their dams were not fed as economically as were those of the third group.

In the fourth group—28 farms—over 80 per cent of the ration was made up of cheap roughage. The cows in this group were carried through the winter at an average cost of $9 per head, or for 5.5 cents a day. This is only one-half the cost of wintering the cows in the first two groups, and nearly $5 less than the cost for the third group. The calf crop in this group averaged only 78.3 per cent. However, a study of the records indicates that this poor calf crop was not due necessarily to the ration. Fifteen of the farms were in Iowa and Missouri, and on these the average calf crop was 91.7 per cent. The remaining 13 farms were in Kansas and Nebraska, where the percentage of calves produced is normally much lower, partly because the cows are not as well cared for and partly because there is more trouble with contagious abortion. The average calf crop for these 13 farms was only 67 per cent, which accounts for the low percentage for the group as a whole. In spite of this low percentage, the calves in this group were produced at an average cost of only $30 per head. Of

these calves sold at weaning time there were only 109, which is hardly enough to be an accurate measure. They, however, made an average profit above all expenses of $2.25 a head.

Approximately two-thirds of the calves in each group were carried through the winter and were inventoried when turned on pasture during the following May. All showed a loss at this time, but the loss was much less for the calves whose dams received the ration of more than 80 per cent roughage. These calves showed a loss of $4.25 per head, as against $15 for those whose dams received less than 40 per cent roughage. The calves in the third group, in which the cows received 40 to 80 per cent roughage, showed a loss of approximately $11.25.

USE AVAILABLE FEEDS MOST ECONOMICALLY.

Beyond the fact that ordinarily the major portion of the ration for these cows should be made up of the cheap roughages or farm by-products, such as cornstalks or straw, there is no fixed rule that should govern the quantity or the kind of feeds used except that the ration should be adequate and economical. Whether the remainder of the ration shall be composed mostly of hay, fodder, silage, or grain will depend ordinarily on local and seasonal conditions.

In years when there is a serious shortage of corn, farmers will find it necessary greatly to reduce the quantity of the corn that ordinarily is fed as grain or in fodder or silage. That this can be done under many circumstances is evident from a further study of the records. They show that a ration which does not contain corn either as grain or in fodder or silage can be fed without any detriment whatever to the cows or their offspring. There were 149 farms feeding such rations, the majority of them in Kansas and Nebraska, and they produced as good calves as the farms feeding corn. The winter feed bill on these farms was $13.10 per cow, as against an average of $16.60 for those using grain, fodder, or silage, showing a saving of $3.50 per head due to elimination of corn.

The use of such a grainless ration, which on these farms consisted solely of hay and cheap roughage, is, of course, not always possible or practicable. If this type of ration is to be economical, there must be an abundance of cheap hay to combine with the rough feeds; or, if the bulk of the ration consists of cheap roughage, which, unless there is some winter pasture, is largely composed of carbohydrates, there should be a sufficient amount of leguminous hay, such as alfalfa or clover, to supply the protein needs of the animal. In localities where there is a shortage of hay but where large quantities of cheap roughage, such as corn stover, straw, or damaged hay, is available, this cheap roughage often can be made to serve as the greater part of the

ration by supplementing it with a small amount of some concentrate high in protein, such as cottonseed meal. The farmers in that portion of the corn belt lying west of the Missouri River, where alfalfa is grown abundantly, nearly always can plan an adequate ration without corn.

THE FEEDING OF GRAIN.

The fact that the 149 farms using the cheaper ration were not feeding corn does not imply that it should never be used, for there are farms where it is necessary to feed a moderate amount of grain. This is particularly true of cattlemen who are conducting a pure-bred business and who advertise their stock by exhibiting at the various live-stock shows. The results of this study simply indicate that care should be taken that no unnecessary quantities of corn are fed.

There were 154 farms (not quite one-third of those studied) on which corn was fed to the breeding herd for at least part of the winter. The average winter feed bill for these farms was $17.10 per head, as against $14.80 for the cows receiving no grain. There were 58 of these farms where less than 10 per cent of the ration was composed of grain and where the cows received an average of 2 bushels of corn and 15 pounds of cottonseed meal per head during the winter. As 42 per cent of this winter ration consisted of cheap roughage and as the amount of feed used was not excessive, the cows were carried through the winter at an average cost for feed of $14.60, or 9 cents a day. In the herds where grain constituted more than 10 per cent of the ration, the cows received an average of from 6 to 18 bushels of corn, much of which was unnecessary. The average cost of feed for wintering these cows ranged from $17.50 to more than $20 a head.

THE USE OF CORN FODDER.

Probably one of the largest wastes of corn occurs in the feeding of unhusked corn fodder, which is extensively fed in sections where corn is the leading crop and where hay is scarce. When corn is relatively cheap as compared with other crops, or when the corn is of poor quality, the feeding of unhusked fodder is, under many circumstances, an excellent practice; but when corn is high-priced, it is usually better to husk out most of the grain and feed the cut stover.

On 148 farms that reported feeding unhusked-corn fodder to their breeding herds, the average winter-feed cost for the cows was $17.10, this being $1.60 above the average winter-feed bill for all farms and exactly the same as for those feeding grain. As would be expected, but little grain or silage was fed on these farms. The fodder also was used to replace hay. It was noticeable that the

farmers feeding unhusked-corn fodder were using much heavier rations (averaging 2,400 feed units) than many of the others. This would seem to indicate that many of the farmers using this ration are merely following a practice that was established years ago when corn was much lower in price.

THE USE OF SILAGE.

In many sections of the corn belt corn fodder is being replaced gradually by silage in the ration for beef animals. Where there are enough animals to justify the building of a silo the feeding of silage is usually the more economical practice of the two, as a much larger proportion of the stover can be utilized as silage than otherwise. Not only is the corn plant more fully utilized, but cattle usually do better on silage than on a dry winter ration.

Silage, because of the grain that it contains and because of the expense of putting it up, is a relatively expensive feed; consequently in localities where large amounts of cheap, rough feeds are available the silo may not always prove economical. However, when such roughage is scarce and high priced the feeding of silage usually will pay. This would be especially true if, instead of cutting their highest-yielding corn, the farmers habitually would select that part of the crop having the least grain. The silo is of especial value in helping to make the most of the corn crop in years when the corn is badly damaged by drought or when because of frosts it does not get a chance to mature.

In years when hay and grain are both high, the putting of husked stover into the silo should prove profitable. Although this practice has not been extensively followed, the results that have been reported seem satisfactory.

The results of this investigation would indicate that silage is an excellent feed for breeding animals, but that from the standpoint of economy it ordinarily should be fed only in moderate amounts and that it should not replace too much of the cheap roughage. One hundred of the farms (or nearly one-fifth of those under consideration) were feeding silage, and their average winter-feed bill was $16 per head. On 29 of these farms approximately 12 per cent of the ration was silage, an average of three-fourths of a ton being fed to the cow. As 41 per cent of the feed was made up of cheap roughage, the silage displaced only fodder and the more expensive hay and grains. The average cost of wintering the cows on these farms was $14. The average quantity of silage fed on the next 50 farms was 1.8 tons, nearly one-third of the ration being made up of this feed. Although the cows on these farms received 100 feed

units less feed, their winter-feed bill was $16.53. In the next group, 21 farms, silage constituted one-half of the ration, the cows receiving an average of 2.75 tons each. As only one-fourth of this ration was composed of the cheaper roughage, the average feed bill for these cows was $17 although they received 400 feed units less than did the cows in the first group. It is evident that on the farms in this third group silage was replacing too largely the cheaper farm by-products.

STUDY OF RATIONS ON SELECTED FARMS.

It is evident from the foregoing that in the corn-belt States many of the farmers who are producing their own feeder cattle need to give more consideration to the rations that are being fed. If farmers will take more pains to find out the nutritive requirements of their stock and will then plan rations that shall be as economical as possible and at the same time adequate, many of them can lower greatly the cost of their winter feed bills.

To show the possibilities of cheapening some of these rations, five farms have been selected, that their winter feeding system may be studied in detail. The farms chosen are representative of feeding practices found in vogue in different places throughout the region covered by the survey. On four of these farms the cows were receiving more feed than they needed, and doubtless on at least three of them the feed was not utilized fully. However, care has been taken not to select any farms of the extreme type. There is only one that was feeding in excees of 3,000 feed units per head during the winter season.

In the discussion of the rations used on these farms, no attempt is made to indicate a ration that shall be fully balanced or that shall be even the most economical. Nor has any study been made to determine whether the rations contain enough minerals for the animals, though generally in the rations outlined there will be a sufficient quantity of these. The suggested changes have been confined to showing that many farm rations can be modified easily in such a manner as to save expense.

FARM NO. 1.

The first of these five farms is in east-central Iowa. It contains 240 acres, of which, for the year studied, 80 acres were in corn, 35 in oats, 50 in clover, and 60 in pasture. The breeding herd consisted of a grade bull and 22 grade cows from which 20 calves were obtained. The cows were given excessive amounts of high-priced feed for both of the years during which records were procured.

They were turned on stalks on November 15. Winter feeding began a few days later and lasted until May 1, when the cows were again turned on pasture. During the 165-day interval each cow received the following:

Stalks	1½ acres, at $1 an acre.
Fodder	⅔ acre, at $35 an acre.
Mixed hay	¾ ton, at $10 a ton.
Corn	2 bushels, at $0.65 a bushel.

As the average yield of corn on this farm was 50 bushels to the acre, and as the best corn was cut for fodder, the cows, considering the corn in the fodder and the additional grain fed, received a total of 22 bushels per head. This is almost a fattening ration. If the corn had been husked from the fodder and only the stover fed, there would have been sufficient roughage for the cows. Estimating that three-fourths of a ton of stover was eaten per acre of stalks and that the stover from the fodder fed would go 2 tons to the acre, and allowing the cows 3 bushels of corn each during the winter instead of 22, they would receive the following daily ration:

Stover	20.6 pounds.
Mixed hay	9.0 pounds.
Corn	1.0 pound.

This ration would be sufficient for their needs.

By merely eliminating the excessive amount of corn (19 bushels) from the ration a saving of $11.40 could have been made and the feed bill reduced very nearly one-half, or from $24 to $12.60 per cow. The calves, which actually cost $43 at weaning time, would then have cost only $30.

FARM NO. 2.

The second farm is in the west-central part of Iowa. It contains 225 acres, valued at $175 an acre. There were 80 acres in pasture, 65 in corn (10 of which were for silage), 30 in oats, and 30 in timothy hay. The breeding herd consisted of a good bull and 20 high-grade cows, from which 20 calves were raised. The cows were turned on stalk fields on November 15 and allowed the run of the fields during the winter. Beginning December 1 they were fed silage, timothy hay, and oat straw. The ration per cow as reported was as follows:

Stalks	1.8 acres, at $0.75 an acre.
Silage	3.5 tons, at $4 a ton.
Timothy hay	1 ton, at $12 a ton.
Oat straw	0.75 ton, at $2 a ton.

This ration contained much more feed than the cows could utilize and probably most of the straw was wasted. It could have been

cheapened greatly by leaving out the timothy hay, which, because of a scarcity of hay in that particular year, was valued at $12 a ton. In addition, 1 ton of silage could have been saved by properly feeding the oat straw instead of allowing the cattle to trample the greater part under foot. Estimating that the stalk fields contained three-fourths of a ton of edible stover per acre, with these changes the daily ration for the cows would have been as follows:

Stover	16 pounds.
Silage	30 pounds.
Oat straw	9 pounds.

This ration contains sufficient dry matter and digestible nutrients to carry the cows through the winter, but the total amount of protein is below the percentage called for by feeding standards. It would, of course, be much better if there were some clover or alfalfa on this farm, so that a moderate amount could replace some of the silage. However, this is the best ration that can be devised from the feeds available. If this farmer would feed from one-half to 1 pound daily of either linseed meal or cottonseed meal, the ration would be greatly improved. Assuming that he purchased 100 pounds of cottonseed meal per cow, costing $2.25, the ration would be adequate and there would still be a saving of $13.75 on the winter feed bill, which would have been reduced from $28.75 to $15. Such a saving in the cost of wintering the cows would mean that the calves, which actually cost $51.50 per head at weaning time, would have been produced for $38, or for only $1 more than the average for all calves.

FARM NO. 3.

The third farm is in a region in southwestern Iowa that for years has had a reputation for prime beef. Many prize-winning carload lots of fat cattle have come from this locality. Because of this reputation there is a certain rivalry among farmers here in the matter of the appearance of their herds, with the result that many of the farmers are inclined to feed more heavily than is necessary. This particular farmer was not feeding nearly as heavily as were some of his neighbors, but it would have been possible for him to feed less and still maintain his herd in good condition and thus effect a saving on the cost of wintering his cows.

This farm comprises 200 acres, of which 50 were in pasture, 80 in corn, 20 in oats, and 30 in timothy and clover. The herd consisted of 22 high-grade cows and a pure-bred bull. The calf crop was kept down by contagious abortion and only 14 calves were saved. The cows were turned on stalks the middle of November. Winter feeding began the middle of January and lasted until they were turned on

pasture May 15. From November 15 to May 15 each cow received the following:

Stalks	2 acres, at $0.75 an acre.
Clover hay	1½ tons, at $8.00 a ton.
Corn	3⅔ bushels, at $0.60 a bushel.
Oat straw	1 ton, at $1 a ton.

The winter feed bill amounted to $16.40. This ration is more moderate and better balanced than that fed on Farms No. 1 and No. 2. However, the amount of clover hay could have been reduced three-fourths of a ton, or to one-half the amount fed, and the corn to at least 1 bushel, if the oat straw had been properly fed and not wasted. The cows then would have received a daily ration of corn 1 pound, clover hay 12½ pounds, and oat straw 16¾ pounds, which should have been sufficient for their needs. In fact, the corn probably could have been safely reduced to 1 bushel and used only during the coldest weather.

This saving of three-fourths of a ton of hay and 1 bushel of corn would have amounted to $6.60 per head and reduced the winter feed bill to $9.70. Because of the very poor calf crop, each calf on this farm had to be charged with the expense of maintaining 1½ cows, besides their proportionate share of the bull charge, and thus their cost at weaning time was $52.60 per head. This cost would have been reduced to $42.25 if the saving above suggested had been effected.

FARM NO. 4.

In eastern Kansas there is a region, covering several counties, that is very much broken and where a limestone formation crops out in many places. These hills, because of the numerous limestone outcrops, are devoted to pasture. Interspersed between the hills are valleys of rich bottom land, where much alfalfa is grown. A large part of this alfalfa is fed to the cattle that run on these pastures during the summer months. The cows in this region are wintered largely on alfalfa, and as this hay usually is very cheap, extravagant quantities sometimes are fed. To contrast the practices followed in this region with those just described for Iowa, a 335-acre farm may be cited. This farm had 130 acres in alfalfa, 20 acres in corn, 120 acres in hill pasture, and 60 acres in waste land and timber. The breeding herd consisted of a pure-bred bull and 30 high-grade cows, which dropped 27 calves. The cows were taken off pasture November 1 and fed until May 1, receiving a ration of one-half acre of stover and 3 tons of alfalfa per head. The stover was valued at $2 an acre and the alfalfa at $5 a ton, the total winter feed bill being $16.

More hay was fed than the cows really needed. Indeed, if the hay had been decreased 1 ton, the ration still would have been adequate, providing sufficient digestible nutrients and more than double the

amount of protein needed. As protein feeds are usually expensive, it is customary to devise rations containing just the necessary amount of this nutrient. However, alfalfa is the cheapest feed available in this case.

Reducing the feed by 1 ton of alfalfa would have cut the winter feed bill $5 per cow. The calves, figuring all expenses, cost $39 each. Considering that each calf bore the maintenance charges of 1.1 cows, as well as a bull charge, a saving of $5 per cow would have reduced their cost at weaning time to $33.50. As they were sold September 15 for $35 a head, this saving would have meant a profit of $1.50 each above all expenses, as against an actual loss of $4.

FARM NO. 5.

The ration used on the fifth farm was very satisfactory. It is shown in order to illustrate how a farmer can grow emergency forage crops to take the place of hay when the hay crop is a failure. This farm (240 acres) is in northeastern Kansas. Seventy acres were in corn, 25 in oats, 25 in wheat, and 100 in pasture. Because of the unusual rainy weather prevailing in that section the oats and wheat for the year in which the record was taken were practically destroyed and the straw was absolutely worthless for feeding. To provide for a lack of hay 15 acres of millet and 4 of sorghum were grown.

The herd consisted of a bull and 15 grade cows, from which 15 calves were obtained. The cows were turned on stalks November 1 and allowed to run there until spring. They received approximately 3 acres of stalks, 1 ton of millet hay, and one-third of a ton of sorghum fodder each. Valuing the millet at $4.50 a ton and the sorghum at $4 a ton, the winter feed cost per cow was $8.20. The cows were carried through the entire year for a net cost of $25.85. The calves cost at weaning time, or October 1, $27.30 per head and sold on that date for $34.50, at a profit of $7.20.

CONCLUSIONS.

The results obtained from this study show that a large percentage of farmers maintaining herds for the production of beef animals do not study their rations carefully in order to determine whether they are properly balanced and at the same time as economical as possible. Many of the farmers visited evidently were trying either to get their cows through the winter as cheaply as possible or simply feeding them enough to carry them through the winter in first-class condition. In contrast to such practices are the methods of dairymen who produce market milk; they have learned by experience that with the prices now prevailing if they are to continue in

the business, they must plan their rations so that they will get the largest possible returns at the lowest possible cost. The corn-belt steer feeders have also learned that with the close margin with which feeding is conducted they also must plan economical rations if they are to succeed. With steer feeding as well as with dairying, much experimental work has been done along this line.

Although it is not necessary to plan the rations for breeding cows as carefully as for dairy animals, or for fattening steers, nevertheless the data obtained show the need of more care on the part of a large number of these farmers in the planning of their winter rations. It is therefore strongly recommended that the farmers who raise their own feeder cattle take more pains to find out the needs of their animals and feed them accordingly. For the benefit of the farmers who are not familiar with methods of working out rations, it is suggested that they write to either their own State experiment station or the United States Department of Agriculture asking for help in planning these rations. In this letter they should state the kinds and qualities of different feeds available for use and the number of stock to be carried through the winter. They also should give a brief outline of how they would like to handle their stock.

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Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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THE CITRUS THRIPS.

By J. R. Horton,

Tropical and Subtropical Fruit Insect Investigations.[1]

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INTRODUCTION.

The citrus thrips [*Scirtothrips*[2] (*Euthrips*) *citri* Moul.] has caused more or less injury to oranges, grapefruit, and lemons in California for the last 20 or 25 years. Owing to its minute size the insect remained undiscovered for many years, and its injury to the fruit was attributed to other causes, such as wind whipping, freezing, etc. About the year 1908 the injury became so severe in Tulare County that the old theories began to be doubted and the need of expert investigation was realized. The preliminary examination in behalf of the Bureau of Entomology was made by Dudley Moulton (2)[3] and resulted in a description of the insect and its injury. Subsequently the bureau undertook a thorough investigation of the life history and control of the insect, this project being started at Lindsay, Tulare County, Cal., in 1909. A report of progress by Jones and Horton (5) and a Farmers' Bulletin on the control of the thrips by the writer (15) have appeared since.

[1] Transferred to Cereal and Forage Insect Investigations, October 1, 1917.

[2] Hood (14) places this insect in the genus Scirtothrips on the apparently adequate grounds that the thorax is finely, transversely striate and the abdomen clothed with minute hairlike processes.

[3] See Bibliography, p. 41.

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HISTORY AND DISTRIBUTION.

Although the citrus thrips has been recognized so recently as the cause of the scabbing and scarring of citrus fruits in California, there is unmistakable evidence that it is native to the orange-growing sections of that State and Arizona. Its present known distribution lies within the arid portion of the Lower Austral life zone in central and southern California and south-central Arizona. It is most abundant and injurious in those sections of this area where the minimum rainfall occurs and where the average summer temperatures are highest, such, for example, as in the San Joaquin Valley, where a climate favorable to the development of the pest and extensive recent plantings of citrus offer an ideal environment. In southern California it becomes seriously injurious only in certain seasons and only in the local sections about Riverside, Redlands, Highland, and Rialto, injury decreasing as the coast is approached. The natural habitat of the citrus thrips, therefore, appears to be the arid Lower Sonoran life zone of North America. This belief is substantiated further by its occurrence on plants native to this region and distant from citrus trees. The citrus thrips is known to occur in eight counties in California (see fig. 1), viz., Sacramento, Fresno, Tulare, Kern, Los Angeles, San Bernardino, Riverside, and Orange. The infestation is most serious in Tulare, Fresno, Riverside, and San Bernardino Counties. In Kern County the insect is increasing rapidly and with increased plantings of citrus doubtless will become quite as injurious as in Tulare County.

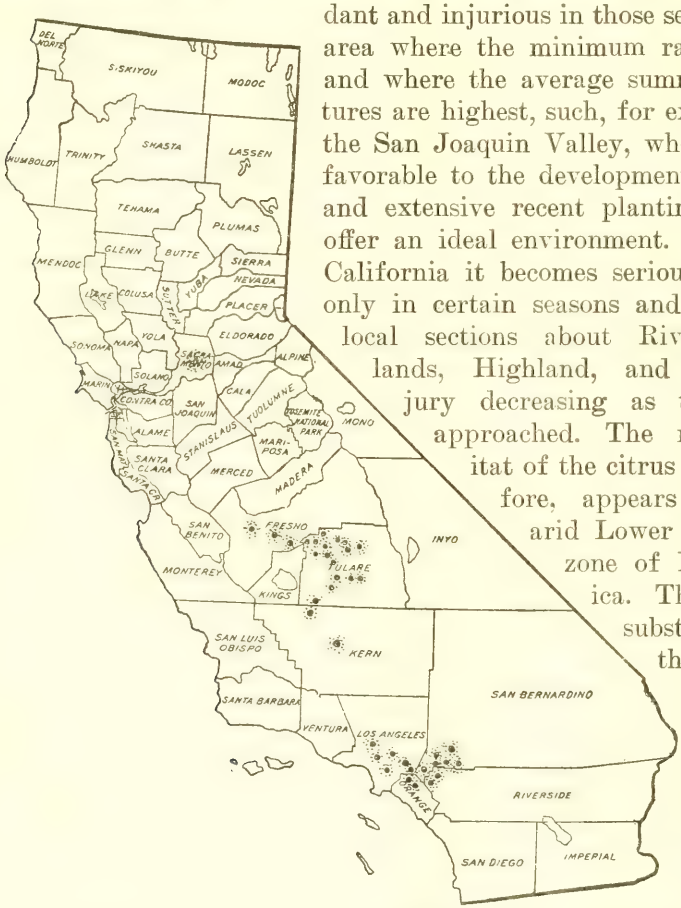


FIG. 1.—Map showing present known distribution of the citrus thrips (*Scirtothrips citri*) in California. (Original.)

Although the insect occurs in injurious numbers in Arizona, thus far it has been taken only in the Salt River Valley near Phoenix and Mesa (fig. 2). Dr. A. W. Morrill informed the writer by letter that he thought he detected traces of thrips injury in an orange grove near Yuma, but specimens have not been taken there.

POSSIBILITY OF ITS OCCURRENCE ELSEWHERE.

No verified reports of the occurrence of the citrus thrips in States or countries other than the foregoing have been made, although it is said to occur at Hermosillo, Sonora, Mexico. There are various reports of thrips injuring citrus fruits, the species concerned being often in doubt. Thus, Tower[1] states that certain scars found on oranges in Porto Rico probably are caused by thrips which were present in the trees in great numbers, but the identity of the thrips is not given. Rolfs, Fawcett, and Floyd[2] describe injury to oranges in Florida by a thrips which appears to be *Frankliniella* (*Euthrips*) *tritici* Fitch, if indeed the injury illustrated by them is caused by thrips. The citrus thrips does not occur in southern Louisiana, and doubtless could not thrive there because of the high humidity and heavy rainfall, and for the same reason probably does not occur in Florida.

FIG. 2.—Map showing present-known distribution of the citrus thrips in Arizona. (Original.)

NATURE AND EXTENT OF INJURY.

The citrus thrips obtains its food by puncturing the tissues and draining the contents of the cells, causing the cell walls to collapse. Growth expansion of the surrounding living cells leaves the punctured and dead areas sunken and distorted. The very characteristic scabbing of the fruit is caused by the dead and dry cell walls being forced outward by the growing cells beneath, the resultant scabs often covering a large portion of the rind. The various rings, streaks, splashes, and other patterns in the tissues result from the almost incessant movement of the thrips as they feed (Pl. I). The

[1] Tower, W. V. Insects injurious to citrus fruits and methods for combating them. Porto Rico Agr. Exp. Sta. Bul. No. 10, p. 20. 1911.

[2] Rolfs, P. H., Fawcett, H. S., and Floyd, B. F. Diseases of citrus fruits. Fla. Agr. Exp. Sta. Bul. 108, p. 32–33. 1911.

"stem-end ring" is the most characteristic form of fruit injury, and is caused by the thrips feeding and ovipositing in a circle under the protection of the sepals when the fruit is small, the injury expanding as the fruit grows. Injury resulting from feeding punctures in mature fruits appears as brownish, glossy discolorations due to cell sap drying on the surface. A large proportion of the badly marked fruit is undersized owing to failure to mature normally, and much of it is at times distorted by failure of the injured tissues to grow.

The more characteristic injury to the leaves is the grayish streaks and areas (Pl. II, fig. 2) and curling. At times cuplike depressions or pockets resembling aphid galls are formed, but oftener the leaves are crinkled or even tightly curled (Pl. II, figs. 1 and 3).

The unfolding leaf buds and especially the terminal buds are often attacked with such severity as to cause them to wither and die, these turning brown or black and finally dropping off.

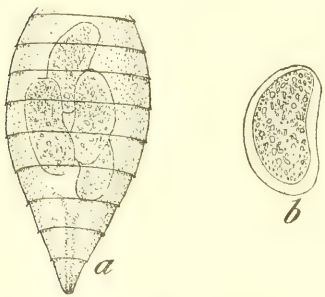


FIG. 3.—*a*, Eggs of the citrus thrips in situ; seen through the abdominal wall. *b*, Single egg of the citrus thrips. Highly magnified. (Original.)

DAMAGE TO FRUIT.

DROPPING.

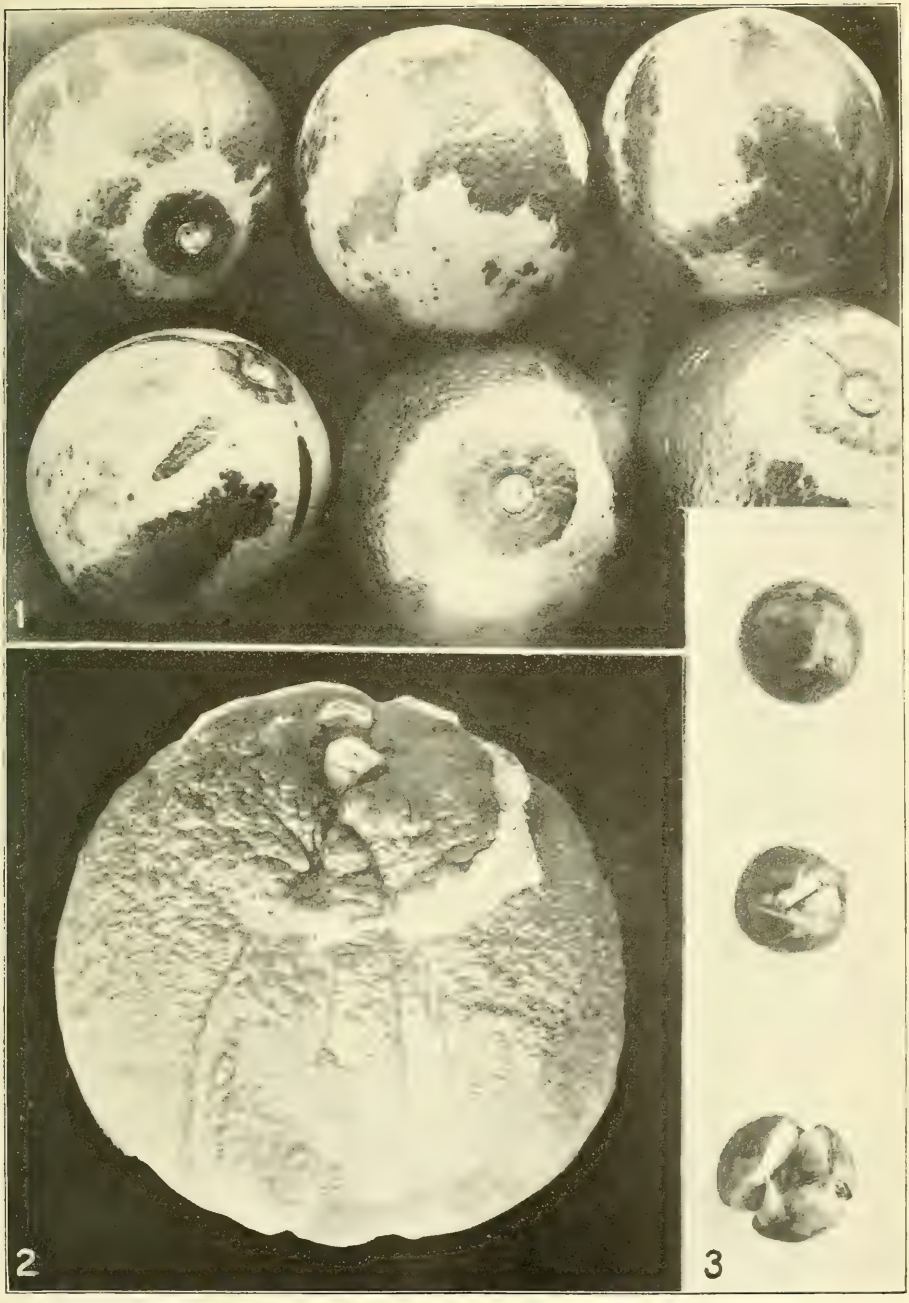
In exceptionally severe infestations, much of the young fruit is punctured over its entire surface during the first three weeks following the blossoming period and thus is prevented from acquiring normal growth, the little fruits eventually dropping to the ground. An appreciable percentage of the crop is lost in this way in certain orchards of Tulare County, Cal., in certain years.

SPLITTING.

While only a small proportion of the usual fruit splitting is caused primarily by thrips, a certain amount of splitting of young oranges does occur every season as a result of the long-continued feeding of thrips over an area usually near the navel end of the fruit. The affected tissues die and dry out and the scabbed area, unable to expand with the growing fruit, cracks (Pl. I).

MALFORMATION.

From less than 1 to as much as 6 per cent of the orange crop, depending upon the orchard and the season, is so badly deformed by the citrus thrips that it must be culled out and sold at the packing house for whatever it will bring. The better culls usually command



CHARACTERISTIC DAMAGE BY THE CITRUS THRIPS (SCIRTOTHRIPS CITRI).

FIG. 1.—Typical citrus thrips scabbing on young oranges. (Natural size.) FIG. 2.—Unusual form of thrips injury on rough orange. FIG. 3.—Splitting of young oranges due to thrips injury. (Original.)

DAMAGE TO THE FOLIAGE OF CITRUS BY THE CITRUS THRIPS.

FIG. 1. Orange leaves distorted and tightly curled by the citrus thrips. FIGS. 2 and 3.—Orange leaves "cupped" by the citrus thrips, showing streaks of dead and discolored tissue. (Original.)

25 cents per box. Although in seasons such as 1911 only a small percentage of the fruit is culled from this cause, in one instance an entire shipment of navel oranges from a 5-year-old, untreated orchard was refused at the eastern market, with the statement that the oranges were too badly scabbed to be salable. In several other orchards inspected that year from 1 to 2 per cent of the fruit was malformed as the result of thrips feeding.

GRADE REDUCTION.

The most important damage resulting from the feeding of thrips upon trees that have passed the period of rapid growth is the lowering of the market value of the fruit by unsightly scabbing and scarring. Although the eating quality of the orange is not affected thereby, its commercial grading is lowered considerably and the selling price correspondingly reduced.

EXTENT OF DAMAGE TO ORANGES IN TULARE COUNTY.

In 1909 more than 80 per cent of the oranges of Tulare County, Cal., were so damaged by the citrus thrips as to lower the grade; in 1910 the grading affected about 63 per cent of the crop, and in 1911 about 65 per cent was affected.

To calculate the loss due to grade reduction because of damage by thrips it is necessary to know the method of grading and relative value of the grades. In California oranges usually are packed in either three or two grades. In the 2-grade pack the quality of the fruit of the first grade is about the same as would be obtained by placing together the first and second grades of the 3-grade pack, the quality being sufficiently lowered to include fruit which would be of second grade in a 3-grade pack.

Taking the season of 1911 as fairly representative of recent years, returns received by different packing houses on a total of about 358,000 boxes of oranges of all grades indicate the following price range between the different grades. First-grade fruit average 37 cents more per box than second grade; the latter 28 cents more than third grade. Receipts from several carloads of fruit shipped in two grades gave an average difference of 51 cents per box in favor of the first grade. Examination of thousands of boxes of oranges throughout the district from Mount Campbell to Porterville showed 34 per cent of the fruit to run first grade, 43 per cent second grade, and 23 per cent third grade, so far as thrips marking was concerned.

Statistics on the amount and value of the total orange crop shipped from the entire San Joaquin Valley in 1911 are not available, but from Lindsay and its tributaries, constituting much the largest single citrus section of the valley, 1,525 carloads, or about 594,750

boxes, of navel oranges were shipped. The loss suffered from grade reduction due to thrips by the Lindsay district alone, and in a season of comparatively light infestation, was therefore about as follows: Forty-three per cent, or 255,742 boxes, reduced to second grade at a loss of 37 cents per box, making $94,624.54; and 23 per cent reduced to third grade at a loss of 65 cents per box, making an additional $88,914.80, or a total loss of $183,539.34.

EXTENT OF DAMAGE IN SOUTHERN CALIFORNIA.

It is calculated that from 20 to 40 per cent of the 1910 orange crop of Riverside County was sufficiently marked to keep it out of first grade. The injury was most severe in groves in the hills to the south and east of Riverside and in the vicinity of Highgrove, where conditions are similar to those along the foothills in the San Joaquin Valley. In this section about 55 per cent of the crop was lowered in grade because of thrips marking. Of the 1911 crop in the same groves, however, only 16.9 per cent was marked sufficiently to throw it out of the first grade.

At Redlands the injury was somewhat less severe than at Riverside. Only from 2 to 5 per cent of the first-grade fruit running in the packing houses was marked, and that slightly, while from 50 to 60 per cent of the second-grade fruit was more seriously damaged. The writer was informed that fruit from some of the groves was injured more severely than that then passing, and when such fruit was being packed an additional or third grade was added to accommodate the thrips-marked oranges.

In the Pomona-Claremont-Upland section damage by the citrus thrips was much less severe than at Riverside and Redlands. The grades of fruit then running were "fancy" and "choice," and it was estimated that about 10 per cent of the first-grade oranges had traces of marking and about an equal percentage of the second, or choice, fruit was more conspicuously marked. The most severe marking occurred at Claremont, which is nearer the hills, a little warmer, and produces very vigorous trees. First-grade fruit was scarred about equal to that at Pomona, but a third grade was run at Claremont, about 25 per cent of which had been reduced because of thrips scabbing.

The injury decreases toward the coast, so that at Whittier only about 10 per cent of the entire crop was scabbed. About 2 per cent of the first and 5 per cent of the second-grade fruit had been slightly marked. Less than 1 per cent of the marked fruit of second grade would be placed in that grade because of thrips injury alone. Lemons were blemished about as much as oranges. At Pasadena 90 per cent of the 2,000 oranges examined in the field was entirely free from

thrips marking; 9.5 per cent had received a few scratches which would in no way affect their value, and only a few oranges were characteristically and severely marked.

INJURY IN ARIZONA.

The amount of thrips injury to citrus in Arizona varies greatly in different groves, depending upon the health and vigor of the trees. It has never been as serious in Arizona as in the San Joaquin Valley, Cal. In the poorer conditioned groves the fruit injury varies from none to 25 per cent scarred sufficiently to reduce the grade. In some seasons the injury has run much higher than this in certain groves. Thus Morrill (9) in 1912 stated that in the various groves injury to the 1911 orange crop ranged from none to about 60 per cent scarred sufficiently to affect the market value, and calculated that there was a 28 per cent reduction of oranges to second grade and a 25 per cent to third grade, and that about 1 per cent were culled partly or entirely because of thrips marking.

INJURY TO TREES.

In many orchards in the San Joaquin Valley the foliage was subjected to prolonged attack from thrips until the functions of the leaves became so disturbed that the trees were prevented from reaching their normal size and fruiting capacity. Stunting due to thrips feeding begins in the nursery. In seasons of severe infestation the leaves and stems of nursery trees are so badly scarred and twisted as to appear blighted, preventing sale at a fair price, and often the growth of the trunk is so retarded that the trees must be held a year or more beyond the proper time for sale in order to meet the size requirements. It sometimes happens that this class of stock is sold along with better trees and, thrips attacks continuing for several years in the orchard, the trees remain undersized and relatively unproductive.

DISSEMINATION.

The spread of the citrus thrips from one citrus-growing section to another is accomplished mainly in the egg stage. The shipping and planting of nursery trees occurs principally from February to May, the transfer of trees being well under way before first-generation larvæ begin to issue from the eggs deposited the preceding fall. Quarantine inspection is entirely inadequate to prevent the introduction of the insect into new districts, since it is practically impossible to detect the eggs of the species. Complete defoliation of the trees prior to shipment accomplishes the destruction of many of the overwintering eggs, but a proportion of them escape because of insertion into the bark of the smaller branches.

A few eggs also pass the winter in the ripening fruit and are thus distributed to practically every part of the United States. Some of these eggs may hatch and survive from fruit marketed in tropical and subtropical climates, but there is very little danger of the insects becoming established in any of the localities where oranges are marketed generally.

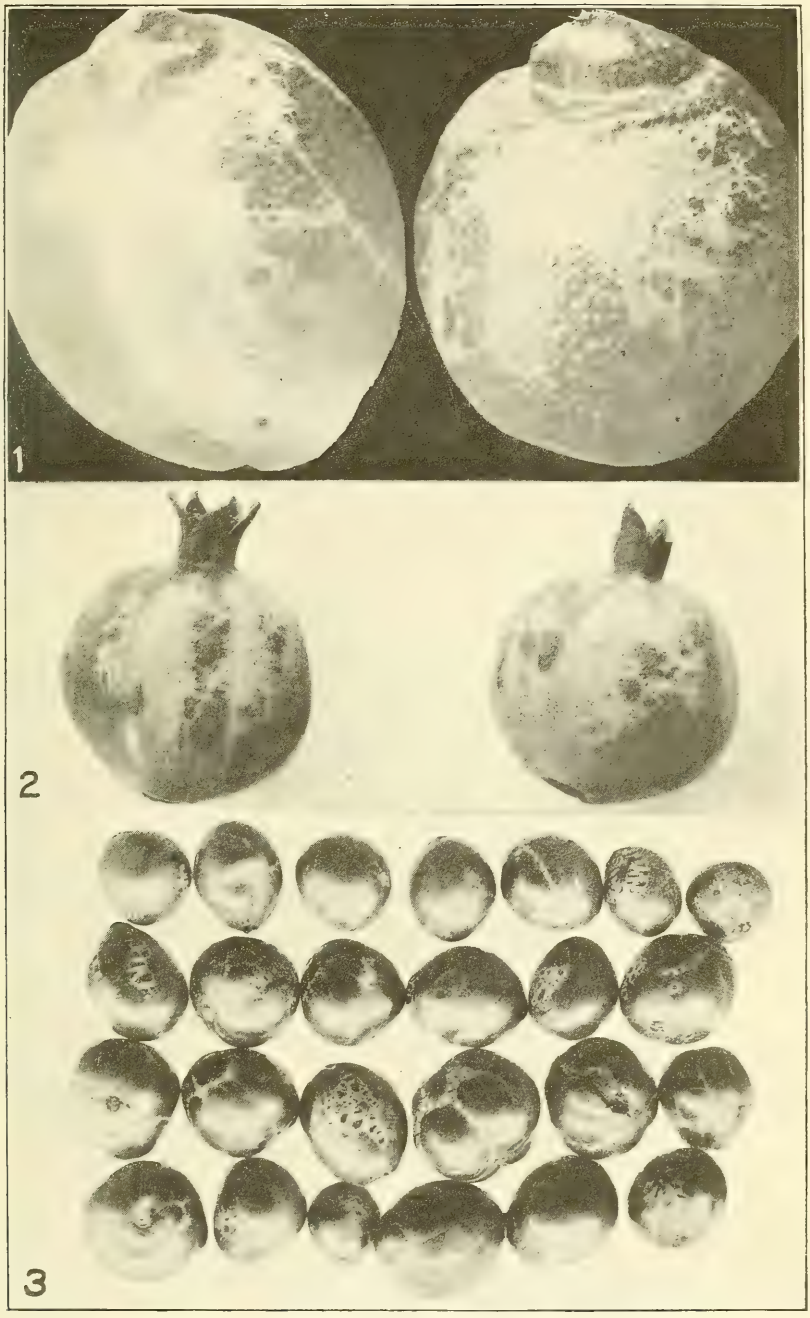
Thrips larvæ are to some extent distributed on nursery stock and, though not so difficult to detect as eggs, would be overlooked very largely in commercial inspection because of their minute size and habit of hiding in crevices in the bark. It is probable that occasionally the larvæ are shipped on fruit, especially on the Valencia orange, but nearly mature fruit has little attraction for them, and it is further probable that few survive the handling incidental to picking and packing.

Local spread is accomplished largely by flight. The citrus thrips is a very ready flier when disturbed or when it desires better food. An observer standing in a favorable position with regard to the light may see numbers of these minute insects leave one tree and make for another, usually disappearing at a distance of 4 or 5 feet because of the light not striking just right. The insect will leave either tree or orchard as soon as leaves, stems, and fruit become somewhat tough. Thus in a grove of young Valencia trees where thrips were present to the number of 80 to 150 per leaf at one examination, not a single adult thrips could be found two weeks later. The explanation was that the leaves had hardened and were no longer suitable as food, while on some older navel trees near by a luxuriant growth of leaves had just reached prime condition for food, and here the insects were found in as large numbers as they had been found on the trees they had deserted.

The citrus thrips usually takes a rapid spiral or zigzag course in short-distance flights, but in extended flights the course is more direct. The flight somewhat resembles that of katydids and grasshoppers. By mounting in a strong wind the thrips undoubtedly would fly a mile or possibly more.

FOOD PLANTS.

Although the citrus thrips thrives best and reaches its maximum abundance on plants of the citrus group, it feeds continuously or occasionally on plants widely separated botanically from the citrus group. In Table I the food plants are arranged according to the extent of infestation as nearly as possible in the order of their importance as food for thrips. There is very little difference, however, in the extent to which the different plants in Group III are infested, and certain plants in Group II are infested almost as badly as any of the citrus fruits of Group I. It will be noted in Table I that the



DAMAGE TO CITRUS AND GRAPES BY THE CITRUS THRIPS.

FIG. 1.—Lemons injured by the citrus thrips. FIG. 2.—Pomegranates injured by the citrus thrips. FIG. 3.—Grapes scarred by the citrus thrips. (Original.)

range of food plants is wide and includes practically all the citrus fruits grown in California, certain deciduous fruits and nuts, a few ornamentals, and several noncultivated plants.

TABLE I.—*Food plants of the citrus thrips in order of importance.*

Group I, generally infested.	Group II, occasionally infested.	Group III, rarely infested.
1. Sweet oranges. 2. Mandarin orange (*Citrus nobilis*). 3. Pomelo, or grapefruit. 4. Lime and lemon. 5. Kumquat (*Citrus japonica*).	6. Pomegranate (*Punica granatum*). 7. Grape. 8. California pepper tree (*Schinus molle*). 9. Chinese umbrella tree (*Melia azedarach umbraculifera*). 10. Apricot.	11. Peach. 12. Plum. 13. Pear. 14. Raspberry. 15. Pecan. 16. Walnut. 17. Olive. 18. Rhubarb. 19. Dock (*Rumex* sp.). 20. Purslane (*Portulaca oleracea*). 21. Willow. 22. Wild morning-glory (*Convolvulus* sp.). 23. Nightshades (*Solanum* spp.). 24. Almond. 25. Tumbleweed (*Amaranthus* sp.).

The sweet oranges suffer greatest damage from the citrus thrips, especially the varieties known as Washington, Thompson's Improved, and Australian navels, and the Parson Brown and Homosassa. Valencias are damaged considerably when the trees are young, and the fruit is attacked at all times, but not severely. Blood oranges generally escape with very little injury. The Washington navel orange covers a greater acreage in Tulare County than all other varieties together. This fact probably accounts for this variety holding first rank as a food plant of the thrips. As a rule not more than 25 per cent of the Valencia crop is injured sufficiently to depreciate its market value; and it is rarely that more than 10 per cent of blood oranges show any marking whatsoever. Oranges of the Mandarin group, especially the tangerines, are subject to very severe marking, for the reason that they remain attractive to thrips until nearly mature. The Satsuma often becomes much distorted because of thrips marking, but this fruit is an unimportant crop in California. Pomelos, limes, and lemons (Pl. III, fig. 1) share nearly equally in severity of thrips marking, but the trees are not often severely injured, as the foliage is not particularly attractive to the insect. Limes often become severely scarred, the rind remaining tender throughout the growth of the fruit. Of all the citrus fruits the kumquat is the least attractive to thrips, rarely more than from 2 to 5 per cent of the fruit becoming slightly scarred by them.

The pomegranate (Pl. III, fig. 2) is the most preferred fruit other than citrus. Pomegranate trees mostly are planted as ornamentals bordering citrus groves, but in 1910 in a 20-acre pomegranate orchard at Lindsay, Cal., 75 per cent of the fruit showed the characteristic scabbing of the citrus thrips. Pomegranates of clear, red

color natural to the ripe fruit are rare in that section, a blending or streaking of the natural red and the gray thrips injury being characteristic. The grape (Pl. III, fig. 3) ranks next to the pomegranate in degree of infestation. It is attacked mostly during the period between growths of the orange. Both leaves and fruit suffer, but chiefly the fruit. In 1911, when citrus trees made but slow and scant growth, a case of severe injury to a small vineyard of Malaga grapes was reported to the writer. This vineyard was located among orange trees which had grown very little during the summer, and the thrips had concentrated there, scarring a large percentage of the berries and distorting many leaves.

Apricots, peaches, plums, and pears are attacked more rarely; raspberry, very rarely. A part of the scabbing found on the pear is probably due to other species of thrips, although new pear leaves occasionally have been found so badly curled by *Scirtothrips citri* that they looked diseased.

The California pepper tree and the Chinese umbrella tree are both very attractive to the citrus thrips, which become abundant on them at certain times of the year. Neither of these trees show the effect of thrips injury from a distance, as do orange trees, and though oviposition takes place in both varieties eggs are not deposited in umbrella-tree leaves in the fall. The insects do not attack the small, berry-like fruit of the pepper tree.

The remaining food plants listed in Table I are attacked but rarely and some of them (almond, walnut, and tumbleweed) are probably only accidental food plants. More thrips have been found occasionally on the common dock than on any other of the noncultivated plants.

LIFE HISTORY AND HABITS.

THE EGG.

DESCRIPTIVE.

The egg (fig. 3), as seen in position through the translucent body wall of the parent thrips, is a bluish-white, bean-shaped object measuring on an average about 0.185 mm. in length by 0.085 mm. in width. It is comparatively very large, so that five eggs in an advanced stage of development occupying the ovaries at the same time cause considerable distention of the abdomen.

When freed from the ovaries, immediately after deposition, the egg is thick at the base, with the upper two-thirds gradually drawn out into a narrower, necklike portion. The color is then clear ultramarine and the surface is smooth and glistening. The membrane is flexible, so that the egg may assume other shapes within certain limits. As the embryo develops the bright-red eyes become visible through the transparent shell.

INCUBATION PERIOD.

The time required for the development of the egg after deposition varies considerably at different times of the year and is influenced largely by the prevailing temperature. There is also some variation among eggs deposited the same day, in the same plant, and kept under precisely the same conditions of temperature. The incubation period ranged from a minimum of 6 days to a maximum of 24 days, the average for the entire season being 16 days. The records on incubation in 1911 are given in Table II. The principal average seasonal variations, together with the prevailing mean temperatures for the periods covered, are shown in Table III. It will be seen that in the cool weather of spring and early summer and again in the fall the incubation period is about two and one-half times as long as in the hottest period of summer. In like manner the egg stage and other immature stages as well are short in exceptionally hot, dry summers, such as those of 1908 and 1909, and considerably prolonged in cooler years, such as 1911.

TABLE II.—*Incubation period of the citrus thrips, Lindsay, Cal., 1911.*

Record No.	Number of eggs.	Deposited.	Hatched.	Duration of stage.	Record No.	Number of eggs.	Deposited.	Hatched.	Duration of stage.
				Days.					*Days.*
1	11	May 4	May 21	17	18	1	May 9	May 26	17
2	61	do	May 22	18	19	1	do	May 27	18
3	15	do	May 23	19	20	1	do	May 28	19
4	6	do	May 24	20	21	1	July 17	July 23	6
5	2	do	May 25	21	22	1	do	July 24	7
6	1	do	May 26	22	23	2	July 22	July 28	6
7	1	do	May 27	23	24	1	do	July 29	7
8	1	do	May 28	24	25	1	do	July 30	8
9	8	May 5	May 21	16	26	1	Aug. 1	Aug. 9	8
10	31	do	May 22	17	27	1	do	Aug. 10	9
11	2	do	May 24	19	28	1	Sept. 6	Sept. 23	17
12	11	May 6	May 22	16	29	3	Sept. 8	Sept. 21	13
13	7	do	May 23	17	30	2	do	Sept. 22	14
14	5	do	May 24	18	31	2	do	Sept. 24	16
15	3	do	May 25	19	32	1	Sept. 18	Oct. 8	20
16	1	do	May 27	21	33	1	do	Oct. 10	22
17	1	May 9	May 25	16					

	Days.
Maximum	24
Minimum	6
Average	16

TABLE III.—*Principal seasonal variations in incubation of eggs of the citrus thrips, Lindsay, Cal., 1911.*

Period of season.	Range.	Average.	Mean temperature.
	Days.	*Days.*	° *F.*
May 4 to May 28	16–24	18.8	64.06
July 17 to Aug. 10	6–9	7.3	81.52
Sept. 6 to Oct. 10	13–22	17.0	62.18

HATCHING.

When ready to hatch, the upper end of the eggshell is broken and the larva pushes through. The first impression on watching a larva issue from the leaf is that the egg itself, or a minute white worm, is being pushed out through the epidermis, the only movement visible being a forward one. When the head and thorax are free, the larva begins a series of vigorous spiral movements which soon liberate the legs and antennæ. In some instances the antennæ retain the folded position until the larva has freed itself completely from the tissue. When the legs are free the insect pushes straight down against the leaf with the third pair of feet and, alternating with abdominal movements, brings itself into position to bend forward and clasp the leaf. It then readily pulls itself out. The entire operation requires from 5 to 10 minutes.

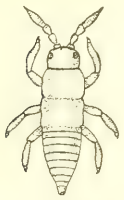


FIG. 4.—First-instar larva of the citrus thrips. Highly magnified. (Original.)

Hatching is not much affected by drying of the leaf or stem tissue. Larvæ have issued from leaves several days after the latter had become thoroughly wilted, and from stems as long as 21 days after they had been cut from the tree.

THE LARVA.

DESCRIPTION.

First-instar larva.—Just after emergence the larva (fig. 4) is colorless and translucent. The head, antennæ, mouth parts, and legs are disproportionately large, giving it an ungainly appearance. The eyes are bright red. The average length is 0.26 mm. (about 0.01 inch). The most distinctive character of the first-instar larva is the narrow, tapering abdomen. In a day or two the body becomes suffused with yellow, which gradually deepens to orange in the fully developed larva. As growth progresses, the head and appendages lose their ungainly appearance and become more symmetrical, and the abdomen grows plumper and less sharply tapering. Shortly before molting to the second instar the average length is 0.45 mm. (about 0.017 inch).

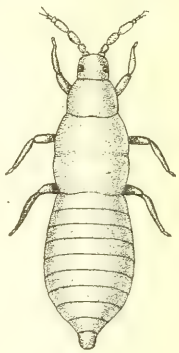


FIG. 5.—Second-instar larva of the citrus thrips. Highly magnified. (Original.)

Second-instar larva.—The second-instar larva (fig. 5) is similar in general appearance to the first, except that it is more robust, more densely pigmented, and the abdomen is broadly spindle-shaped, tapering gradually from the middle segments in both directions. The color varies from light yellow to deep orange yellow, and occasionally cream-colored in-

dividuals occur. The eyes are dull red to dark purple. The average length varies from 0.45 mm. (about 0.017 inch) at the beginning of the instar to 0.90 mm. (about 0.035 inch) just before molting to the propupa.

FEEDING HABITS.

The larva becomes active immediately after emergence, moving about over the leaf or stem, swinging the antennæ up and down, and surveying its surroundings for a place to feed. When feeding, the citrus thrips does not insert the mouth-cone itself into the plant tissues, and thus does not cause holes and raggedness in the leaves, as the pear thrips does, for example. The feeding puncture of the citrus thrips is made by bringing the tip of the cone into contact with the surface of the plant and moving the head quickly downward and slightly backward. This movement results in a slight folding, or elbowing of the cone at a point near its juncture with the head and in some way exerts a leverage upon the lancets, which are thus pushed into the tissue, starting the flow of cell sap, which is sucked up through the tubular interior of the cone.

DURATION OF LARVAL FEEDING STAGE.

The first of the two instars or stages of growth of the larva ranged from a minimum of 1 day to a maximum of 13 days, with an average of 3.7 days, in specimens in which the actual casting of the skin was observed. The second instar of these specimens ranged in duration from 2 to 9 days, with an average of 4 days. An abnormal maximum of 29 days was reached by one specimen in November, the insect ultimately dying from exposure to prolonged low temperatures, without changing to the propupa. The two larval instars may be said to be of about equal duration.

The duration of the complete or feeding stage of the larva ranged from 3 to 21 days, the average for the entire period from March 25 to November 5 being 7.8 days. Great individual variations in the length of the immature stages are to be expected and do not have any particular significance in a practical way, but a knowledge of the average variation in different periods of the season and in different seasons, due largely, as they are, to climatic factors, are of value in predicting what the severity of a given infestation will be. The principal seasonal variations in the duration of the larval stage, with a record of the prevailing temperature, which is the principal factor affecting the length of the stage, are given in Table IV. It will be seen that in seasons such as 1911 the larval stage will range from about 4½ to 7 or 8 days in the period from about the middle of May to the middle of September, and in the cooler weather of March and April

and from the latter part of September to November it will range from about 12 to 14 days.

TABLE IV.—*Seasonal variations in duration of the larval stage of the citrus thrips, Lindsay, Cal., 1911.*

Period of season.	Average duration of the larval stage.	Prevailing mean temperatures.
	Days.	° *F.*
Mar. 25 to Apr. 15	13.7	59.62
May 13 to June 3	8.2	62.58
June 13 to Sept. 5	4.4	74.61
Sept. 4 to Sept. 21	6.8	67.47
Sept. 23 to Nov. 5	11.8	58.48

MOLTS.

All four molts of the citrus thrips, comprising two in the larval stage and two in the pupal stage, are accomplished in about the same manner. The first molt takes place on the leaves and fruit of the host plant, the remainder in some secure hiding place, usually on the ground. When ready to molt the larva ceases to feed and becomes inactive. Tremors vibrate the antennæ and body at brief intervals for a period of from one to three hours, and the abdomen slowly contracts and shrinks away from the old skin. Then follows an active period of from 15 minutes to an hour, in which the middle and hind legs are repeatedly stretched as far back as possible and slowly drawn forward, while the insect goes through jerky lateral motions with the body. The skin then splits from the vertex along the dorsum to the abdomen, after which the insect becomes very active, doubling down with the head between the fore feet and slowly removing the skin from the head and antennæ. The legs are then worked out of their casings and the exuvium pushed back under the body. The skin usually is attached at the tip of the abdomen to the surface on which molting occurs, greatly aiding the insect in extricating itself. The skin generally is removed entire, but occasionally antennal and leg casings are removed separately. Cool weather greatly retards the process, which is more likely to be observed when such weather prevails. Groups of larval skins resembling specks of gray dust sometimes are found on orange leaves. The molting process in the citrus thrips is similar to that observed in certain Orthoptera.

THE PUPA.

DESCRIPTION.

The propupa.—The propupa, or first instar (fig. 6), is very similar in general appearance to the larva. It is generally somewhat paler

in color. The antennæ are directed forward and are 4-jointed. The eyes, at first almost colorless, finally show a red pigmentation in about two-thirds of the facets. The wing pads, which are almost colorless, transparent saclike projections, the hind pair projecting slightly farther than the fore pair, extend to or slightly beyond the hind margin of the second abdominal segment at the beginning of this instar and reach to the hind margin of the third segment before transformation to the second-instar pupa.

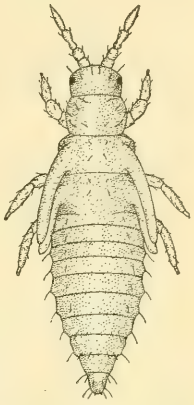


FIG. 6.—First-instar pupa of the citrus thrips. Highly magnified. (Original.)

The second-instar pupa.—The second-instar pupa (fig. 7) is at first but slightly larger than the advanced propupa. The color is pale, translucent yellowish. The antennæ are apparently 4-jointed, but the exact number of joints is confused by the ringed appearance due to transitional tissues seen through the pupal sheath. They are directed backward over the head and prothorax, extending to a point near the middle of the latter. All facets of the eyes are red pigmented. The ocelli are visible and translucent. The wing pads at first extend to the hind margin of the sixth abdominal segment or slightly beyond, but project as far as the ninth or tenth segment just before the molt to the adult. Long weak spines are moderately conspicuous on antennæ, legs, and hind angles of the abdominal segments.

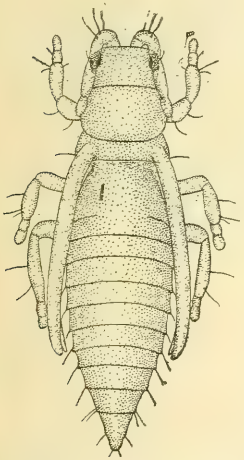


FIG. 7.—Second-instar pupa of the citrus thrips. Highly magnified. (Original.)

There is less growth in the pupal stage than in the larval stage. The average length soon after the molt to the propupa is 0.70 mm. (about 0.027 inch); shortly before the first pupal molt it is 0.72 mm. Just before the last molt it averages 0.80 to 0.84 mm. (about 0.03 inch). The wing pads increase on an average about 0.04 mm. in length during the first instar, and show a gain after molting to the second instar of 0.10 to 0.12 mm. After the molt to the adult stage the wings exceed the tip of the abdomen.

PLACE OF PUPATION.

Certain Thysanoptera, notably the pear thrips, congregate in large numbers during pupation, and a knowledge of this habit may lead to a means of effective control. The citrus thrips, however, has no definite place of pupation. The second-instar pupa is more exposed to the attacks

of predatory insects than any other stage, and therefore pupation occurs in places practically inaccessible to any but the smallest insects and mites. The pupæ are scattered widely, thus limiting the possibility that any great number will be destroyed at one stroke. They have been found in the following situations: On the ground under the trees; in curled, dried leaves, and under a mat of fine cobweb and dust on dry leaves; in the split tips of leaf stems; in small crevices in the bark of dry twigs. In clean-cultivated young orchards, where but few dead leaves and twigs collect, the thrips pupate in crevices near the base of the trunks, under dead and living fluted scales (*Icerya purchasi* Mask.), and in similar obscure situations. In only two instances was pupation found to have occurred on the upper part of the tree: One in which a propupa was found in a distorted leaf, and another in which one specimen occurred under the cocoon of a caterpillar on an orange leaf. To find pupæ of the citrus thrips requires a minute and painstaking search. If no better shelter offers, the insect gathers particles of dust, wood, leaves, etc., about itself, effectively concealing it. In captivity a large proportion of the pupating specimens crawled into the cotton plugs of the rearing bottles and under the split bark at the ends of orange stems used as food. No food is taken during the pupal stage.

DURATION OF THE PUPAL STAGE.

The duration of the pupal instars may be accurately determined, as once a spot has been chosen for pupation the insect seldom moves from it, and cast skins of the last larval and both pupal transformations generally remain nearby. The first pupal instar ranged from 1 to 9 days, with an average for the entire active season, from April 1 to November 8, of approximately 2 days. The second instar ranged from 1 to 25 days, with an average of 5.5 days for the period from April 4 to December 2. The 25-day maximum period is of course exceptional, and would occur in comparatively few individuals of very late hatch.

The entire variation in duration of the complete pupal stage in the period from April 1 to December 2 was from 2 to 28 days, with an average of 7.5 days. The important general variations in the length of the pupal stage in different periods of the season are shown in Table V. It will be seen that growth of the pupa, as well as of the egg and the larva, is slow in the cool weather of spring and fall, when the temperature ranges between 50° and 60° F., and that it is considerably accelerated in midsummer, with temperatures above 60° F.

TABLE V.—*Seasonal variations in duration of the pupal stage of the citrus thrips, Lindsay, Cal., 1911.*

Period of season.	Average duration of the pupal stage.	Prevailing mean temperatures.
	Days.	°*F.*
Apr. 8 to Apr. 26	13.2	56.52
May 3 to May 13	8.4	58.08
May 22 to June 4	5.5	64.74
June 2 to Sept. 5	3.5	76.55
Aug. 31 to Sept. 26	5.3	68.20
Sept. 21 to Oct. 28	7.3	60.70
Oct. 18 to Dec. 2	15.4	51.04

THE ADULT.

DESCRIPTION.

The adult citrus thrips (fig. 8) is among the smallest of insect pests and is smaller than most of the more injurious related Thysanoptera. The female measures from 0.60 to 0.88 mm. (about one-fiftieth to one-twentieth inch) in length; the male, which is noticeably smaller, measures from 0.51 to 0.65 mm. The color of the adult is translucent

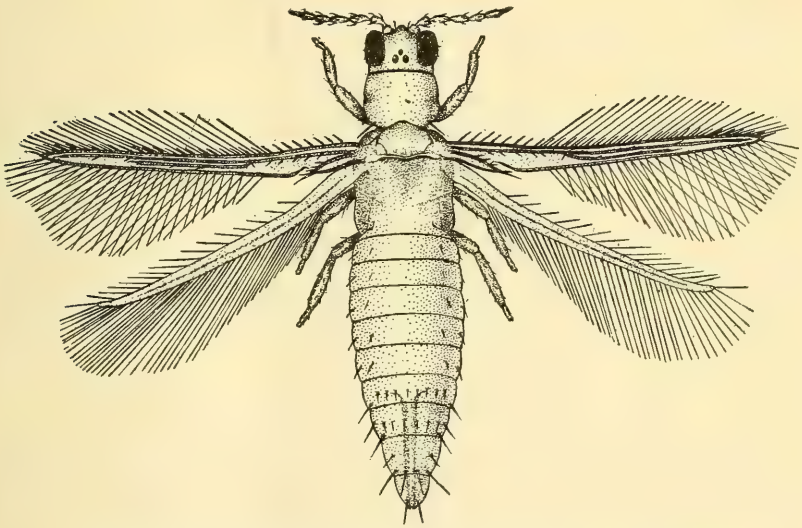


FIG. 8.—The adult female citrus thrips. Highly magnified. (Original.)

orange-yellow; the male is somewhat paler than the female. The head is small, about one-half as long as wide, and a considerable portion of it is occupied by the large compound eyes, which are dark purple to black. Three transparent ocelli, or simple eyes, bordered by reddish brown crescents, occupy the space between the compound eyes on the upper surface of the head. The antennæ are 8-jointed; some of the segments are furnished with transparent sense organs.

The rostrum, or mouth-cone, is short and blunt, not quite reaching across the prothorax, and is tipped with black. The prothorax is slightly wider than the head, slightly narrower than the mesothorax. The female is broadest through the middle segments of the abdomen, tapering gradually both ways; tip of the abdomen conical, fitted with a sawlike ovipositor. The abdomen of the male tapers gradually from the second segment to the tip, which is bluntly rounded; a pair of reddish brown testes is visible through the body wall at the sixth and seventh segments. More or less conspicuous spines occur on the wings and near the hind angles and at the tip of the abdomen. Under high magnification the abdomen is seen to be regularly beset with minute hairlike processes.

DURATION OF ADULT LIFE.

Owing to their extreme activity, minuteness, and delicacy, many of the adult thrips under observation were killed accidentally and others probably injured in changing their food. For this reason only the data upon specimens which lived 20 days or longer are considered in discussing the length of adult life. In only a small percentage of the cases considered did the length of life run as low as 20 days. The maximum duration was 49 days, which is also probably exceptional. The variation of 29 days occurring between the accepted minimum of 20 and the maximum of 49 days is probably as great as ever occurs in the field among specimens not affected by accident, disease, or enemies. In nearly 70 per cent of the cases considered the insects lived 25 days or more, and in 85 per cent they lived 35 days or less. The average age attained by the shortest-lived specimens may therefore be set safely at 25 days, and that of the longest lived at 35 days, the mean between the two being 30, which corresponds closely with the general average from all which lived over 20 days. The insects lived only from 3 to 6 days without food.

INFLUENCE OF THE WEATHER ON GROWTH AND BEHAVIOR.

The citrus thrips is purely a product of the arid Southwest and flourishes only in a hot sunny climate. The fact that it does not thrive in coastal sections nor in any part of the humid belt of the Lower Austral life zone shows its sensitiveness to conditions of temperature and moisture. The insect flourishes best on sunny hill slopes. It appears to enjoy the direct rays of the sun, and by preference seeks the more exposed leaves and fruits in the upper and southerly expansion of the trees. On bright warm days of summer the adults exhibit marked restlessness and increased reproductive activity. The duration of the immature stages is shortened, molting is accelerated, and the rate of emergence is increased greatly. The

number of generations is greater in exceptionally long hot summers than in more moderate ones.

Cool, cloudy, or rainy weather, on the other hand, at once markedly diminishes the various activities of the insects. They then seek shelter in groups in the pits or curls and on the underside of the leaves, about the stem ends of the fruit, and in the crotches and angles of the stems. Growth, molting, and emergence are retarded. With temperatures ranging between 40° and 50° F., in November and December, larvæ and pupæ often live fully a month without change, scarcely feeding at all, and as the weather continues to grow colder both they and the adults die off, leaving only unhatched eggs to produce the succeeding spring generation.

PECULIARITIES OF INFESTATION DUE TO FEEDING HABITS OF THE ADULT THRIPS.

Feeding only upon the newer tissues, the adult citrus thrips are active in selecting young and healthy trees and often suddenly migrate from one set of trees to another or from one orchard to another. In localities where, owing to favorable cultural conditions and large plantings of young trees, an abundance of new shoots occurs in a close succession of growths, adults will congregate in immense numbers and remain throughout the season. The resultant damage in such localities is often entirely out of proportion to that occurring in other parts of the same district. The explanation of excess infestations in certain orchards and in certain localities is simply food preference. Areas of this sort occur typically along the foothill slopes, both in the San Joaquin Valley and near Riverside and Redlands.

In older orchards, where some of the trees have been cut back and rebudded, thrips will congregate on the watershoots and buds from every part of the orchard and in such numbers as greatly to retard the growth of the buds. The damage done in old orchards surrounded by young trees is often very slight for the reason that the thrips confine themselves almost exclusively to the latter. In seasons like 1911, when the climatic conditions are such as to minimize growth, the insects are compelled to feed to a greater extent upon the fruit with consequent greater damage.

OVIPOSITION.

DESCRIPTION OF PROCESS.

The following is a description of oviposition under natural conditions as observed in a single specimen at night during cool weather, the observations being made with the aid of an electric pocket lamp and a hand lens. Attention was first attracted to the specimen by its indifference to the light. For a half hour it remained in a space

about an inch square and went through the following antics: Frequently it would elevate the abdomen, spreading the wings as in preparation for flight. Then it would crouch flat to the leaf, twisting the abdomen about with a rotary motion, at times leaning far over to one side and often moving backward, slowly turning about in a complete circle. At one time the insect turned completely over and lay on its back for a short space, the abdomen continuously moving as described. At the end of a half hour the ovipositor was slightly exserted from a point very near the tip of the abdomen, which was then arched and its tip brought into contact with the leaf surface. The ovipositor was then inserted in the leaf in a single movement from an almost vertical position to about two-thirds its length. The insect then relaxed slightly and remained quiet in this position for four minutes, when it moved away and rested. Only one egg was deposited.

PORTION OF PLANT SELECTED FOR OVIPOSITION.

The citrus thrips oviposits only in those tender tissues which are suitable for food, i. e., the new growth and the young fruit. Eggs are deposited largely in the leaves and fruit in summer and in the stems in fall, more particularly the large tender stems of the orange tree. In summer large numbers of eggs are thrust into the new leaves, leaf stems, fruit and fruit stems, and when the petals have fallen the fruit receptacles become a favorite place of oviposition, which is accomplished under the protection of the sepals. Eggs are never deposited in the blossoms.

RELATION OF QUALITY AND AMOUNT OF FOOD TO OVIPOSITION.

Eggs are never deposited in the older leaves and stems and but rarely in the fruit after it is two-thirds grown. The number of eggs deposited in a particular tree will depend exclusively upon the amount of new growth produced by that tree. It is impossible to induce the insects to oviposit in the tough leaves of potted orange trees, though hundreds have been confined upon such plants for many days. Eggs were deposited readily in the same kind of plants when one or more new leaves occurred there, even though only 20 to 25 insects were confined through one night only.

Oviposition does not occur in the minor food plants (including the Valencia orange, pomelo, lemon, pepper tree, Chinese umbrella tree, and grape), regardless of growth, in as great proportion to the number of infesting insects as in the Washington and Thompson's navel oranges.

RATE OF OVIPOSITION AND NUMBER OF EGGS DEPOSITED.

The preoviposition period in midsummer, when metabolism is rapid, is three or four days. The highest average daily rate of egg

deposition was secured in two experiments, in which the insects oviposited at the rate of 0.7 egg each per day. This is probably below the normal rate in the field in summer. The largest number of eggs occurring in the ovisac at one time and developed sufficiently to be observable with the ordinary powers of the microscope is five, and it is improbable that more than this number would develop and be deposited in one day. In 1911, of 1,050 female thrips collected monthly from April to October, inclusive, developed eggs were absent from 644, which may have oviposited just before captivity and were therefore not taken into account. In the remaining 406 insects there were 493 eggs, an average of 1.2 each. The percentage of thrips with only one egg visible was 80.7 per cent; with two eggs present, 17.1 per cent; and with more than two, but 2 per cent. It may be inferred from these data that on an average a single specimen will not deposit more than one egg per day, though the number will vary slightly with the character of the season and the quality and amount of food. Rarely as many as five may be deposited.

It would seem that in cool seasons such as 1911 the citrus thrips will deposit, on an average, only from 26 to 70 eggs in the course of her life, and this is believed to be one of the chief reasons for the relatively light infestation of thrips in that season as compared with such seasons as 1908 and 1909. In such exceptionally favorable seasons as the last mentioned it is possible that a large proportion of the insects might live the maximum of 49 days and deposit the maximum of 5 eggs each per day, making a total of 245 eggs for the individual.

DURATION OF THE LIFE CYCLE.

The duration of the life cycle was determined by two methods, viz, by the complete rearing of individual specimens through all the stages and by adding together the number of days in the egg, larval, and pupal stages. Owing to difficulties in handling only a comparatively small number of insects (13 to be exact) were carried through all the stages. From this record, obtained in May and early June, 1911, a maximum life cycle of 31 days, minimum of 28 days, and average of 29.8 days were secured. From the abundant data assembled in determining the duration of the separate immature stages the life cycle was found to be 33.9 days in May and early June and 29.1 days in September, months in which the weather was moderately cool; and in the period from June to September, during the hot weather, it was 15.2 days. The data are given in detail in Table VI. The figures do not take into account the three or four days between emergence and the first oviposition, which should be added for the complete life cycle.

TABLE VI.—*Duration of the life cycle of the citrus thrips, Lindsay, Cal., 1911.*

Period covered.	Average length of egg stage.	Average length of larval stage.	Average length of pupal stage.	Average duration of life-cycle.	Mean daily temperature.
	Days.	*Days.*	*Days.*	*Days.*	°*F.*
May 3 to June 9	18.8	8.2	6.9	33.9	62.67
June 2 to Sept. 5	7.3	4.4	3.5	15.2	76.03
Aug. 31 to Sept. 26	17.0	6.8	5.3	29.1	68.12

SEASONAL HISTORY.

About the middle of October the thrips begin to diminish noticeably and as the temperature goes lower, through November and December, they gradually disappear. Occasionally adult thrips will be found on the trees as late as December, from which it has been inferred that the winter is passed in this stage. As a matter of fact none of them lives through the month of January, and even the most painstaking search has never revealed a single specimen of larva, pupa, or adult later than January 5. Dead adults occur in increasing numbers on the leaves in October and November, corresponding with the period in which the living insects disappear most rapidly. It was determined by experiment, verifying field observations, that the winter is passed successfully in the egg stage only. Large numbers of adults and larvæ confined in the fall on orange plants, practically exposed to the prevailing weather except for being sheltered from rain, began to die early in November, very few larvæ pupating and these few dying as pupæ. All specimens were dead by December 26, but the eggs deposited produced larvæ the following spring.

The earliest time at which the citrus thrips have been found in the spring was March 25. There is, therefore, a period of from 8 to 11 weeks in January, February, and March in which feeding, oviposition, and all other activities of the insect cease, but which can not be called a hibernating period in the strict sense. The late issuing larvæ, as well as the pupæ and adults found in November and December, feed during the warm part of the day until the first severe frost kills them. The date of issuance of the first spring larvæ will depend upon the character of the season, coming early when the mean temperature for February and March is high and being delayed by a late cold spring.

MOVEMENTS OF THE THRIPS IN RELATION TO THE BLOSSOM AND GROWTH PERIODS OF THE WASHINGTON NAVEL ORANGE.

As the stems from which the first spring larvæ issue harden, the insects wander in search of better food and are soon found working up onto the new spring growth, which is usually 8 or 10 inches long by the time the larvæ have attained considerable numbers. Orange

growth and the appearance of thrips larvæ occur about 10 days earlier on the foothill slopes than on the valley level. Adult thrips begin to appear rapidly about the time the Washington navel trees are in full bloom, and the growth from 1 to 3 feet long, usually about the middle of April, and the resultant oviposition and feeding on the spring growth soon bring their injury into prominence. About the time one-third or more of the petals have fallen the first growth of foliage begins to harden and the thrips transfer to the little fruits. This period of transfer usually will fall between April 15 and May 30, depending upon conditions of growth and bloom.

The first injury to the fruit is caused largely by a comparatively few of the first larvæ which issue from it, feeding deeply in a circle about the stem, the injury so made eventually developing into the ring scars typical of citrus-thrips injury. Severe injury to the fruit begins as soon as the petals drop, increasing from that time until the oranges average about the size of a tennis ball. The more serious damage usually is done between the middle of April and the early part of July. Adult thrips then begin to leave the oranges, which become tough and distasteful to them, and transfer to the second growth of foliage. A few thrips feed and oviposit on the fruit practically throughout the season, however, and slight injury may often occur until the last of September. In 1911, the leaf growth was sparse and the amount of late injury to the fruit was unusual, being considerably greater than had been expected from the relative scarcity of thrips.

MIGRATION OF THRIPS TO SECONDARY FOOD PLANTS DUE TO SCARCITY OF ORANGE GROWTH.

The transfer of thrips from oranges to the secondary food plants takes place every season in greater or less degree, depending upon food conditions. The scarcity of suitable citrus food in 1911, approximately from June 30 to August 30, led to an unusual increase of the insects on certain other plants during that period. Grapes are especially subject to infestation at such times, and one case was reported to the writer in which both leaves and berries of a small vineyard were severely injured. During this period in which the thrips are scattered widely over their various food plants—roughly, during June, July, and August—reproductive activity is at its minimum.

CONGREGATION OF THRIPS ON LATE SUMMER GROWTH OF CITRUS.

Washington navel and Valencia orange trees in the San Joaquin Valley make from three to six successive new growths during the summer, depending on weather conditions, care of the grove, and age and health of the trees. In exceptionally favorable seasons there is

some new growth on the trees throughout the summer, but ordinarily there are two periods in which the growths are most attractive to thrips, one occurring in May and June, the other in August and September. During the August–September period the tissues of most of the deciduous food plants and the rind of the oranges are tough and distasteful, and there is a steady, often sudden, influx of thrips from scattered locations to the new foliage of the orange and some other citrus. The insects apparently become more numerous than ever, being more closely concentrated than at any other time of year.

In this period of the season, therefore, the following conditions favorable to the thrips progeny of the ensuing spring usually occur: The food supply is abundant and concentrated. The proportion of male thrips is increased, and mating and oviposition occur to a much greater extent than at any other time. This most favorable circumstance of abundant food in comparatively small space at just the time when the insect must produce the eggs for the next summer's generation is a principal factor in the rise of the species as a pest. It has been brought about by the occurrence in recent years of large numbers of vigorous young orange trees which the thrips was able to substitute for the miscellaneous weeds previously constituting its food supply.

GENERATIONS.

It is impossible to distinguish between generations of the citrus thrips, except perhaps the first and second summer generations, when growth is slow. Throughout the middle of the summer the life cycle occupies from 15 to 16 days, while oviposition covers from 25 to 30 days. Thus the complete life cycle may be passed by any given lot of individuals and eggs deposited by them to begin another generation while their progenitors are still ovipositing. This causes an overlapping of broods, such that it is impossible to distinguish between them. The number of generations will depend, of course, upon the character of the season. An early, warm spring followed by a prolonged, hot summer may result in the production of eight or more generations. In seasons such as 1911, six full generations may be expected between the middle of April and the first of November.

NATURAL CHECKS.

FREEZES.

Practically all sections of California where oranges are grown are subject to occasional freezes of varying severity, which always occur between November 15 and March 1, when the citrus thrips are practically all in the egg stage in the leaves and stems. The shoots most severely injured by freezes are those in which a majority of the eggs

are deposited, and thus it occasionally happens that a considerable number of the eggs are frozen. In the winter of 1911-12 more or less severe freezing occurred throughout the citrus-growing sections of the State. The leaves and stems of the principal summer's growth were browned and withered, and the thrips suffered a considerable reduction in numbers in many orchards. For example, an orchard which had been severely infested by thrips during the three years from 1909 to 1911, inclusive, and particularly in 1911, when the entire crop was rejected because of thrips scabbing, was frosted so badly during the winter of 1911–12 that the tender leaves and stems were wilted and blackened well down into the leaf expanse of the trees. In August, 1912, examination of the fruit from this orchard showed only 13 per cent of it to be marked by thrips, the degree of injury being noted at the time as mostly very slight stem-end rings. Thrips were very scarce and the leaves showed little injury except in scattered spots.

RAINS.

From the fact that rains are supposed to be a powerful agency in the natural control of some species of thrips, it has been argued that a season of unusually heavy rainfall would reduce greatly the number of citrus thrips. Whatever merit rainfall may have in checking thrips of other species, its effect on the citrus thrips under the conditions prevailing in the San Joaquin Valley and in Arizona could not be of the least importance, since the heavier rains do not begin there until October at the earliest, and usually not before November or December, by which time almost all the overwintering eggs have been deposited. In spring the rains cease before the thrips emerge in any considerable number. The season of 1909, following the heaviest rainfall in the three-year period from 1909 to 1911, inclusive, in the San Joaquin Valley, was the worst season for thrips injury on record.

NATURAL ENEMIES.

INSECTS.

The most important insect enemy of the citrus thrips is the larva of the common lacewing fly of California (*Chrysopa californica* Coq.).[1] In its early stages this larva feeds largely upon larvæ of the citrus thrips. In October, 1911, an examination of 10 one-year-old orange trees on which thrips were numerous disclosed an average of 25 eggs of this Chrysopa per tree. A number of the sickle-jawed larvæ were also present in the trees, and several of the smaller ones were engaged busily in feeding upon thrips. The thrips were indeed almost the only food available to the lacewings in quantity on these

[1] Identified by Nathan Banks.

trees. Adult thrips suffer from the lacewings only when the weather has become so cool as to make the thrips sluggish.

In its early larval stage, the lady beetle (*Hippodomia convergens* Guér.) feeds upon the citrus thrips. Although this Coccinellid is extremely numerous throughout the Tulare County citrus belt, it feeds mostly upon aphids and other larger insects which occur on orange trees and more particularly on truck crops, and is of no great importance in destroying the thrips.

A thysanopteron enemy of the citrus thrips which seemed to be increasingly important in 1912 was the 6-spotted thrips (*Scolothrips sexmaculatus* Perg.). The principal food of the 6-spotted thrips, however, appears to be mites which occur mainly on plants other than citrus in Tulare County and which are not numerous enough on orange to attract large numbers of the predatory thrips. This thrips is apparently just learning the possibilities of abundant food offered by the citrus thrips, and perhaps will feed more extensively upon it as time goes on. It is apparently unable to catch the adults and therefore feeds only upon the larvæ.

The younger nymphs of one of the assassin bugs (*Zelus renardii* Kolen)[1] are fairly common upon orange trees in Tulare County and have several times been seen feeding upon larvæ of the citrus thrips. The more advanced assassin bugs, however, feed principally upon larger, and often harmless, insects and it is only in their first and early second instars that they attack thrips.

The small reddish nymph of the plant bug (*Triphleps insidiosus* Say) has occasionally been seen feeding upon flower thrips in orange and several other blossoms. When imprisoned with *Scirtothrips citri* it flourished very well upon the latter, but when the flower thrips (*Frankliniella tritici* Fitch.) was also placed in the bottle the latter proved more attractive to the insect, doubtless because of its larger size and greater sluggishness of movement. *Triphleps insidiosus* has not been seen upon orange trees after the blossom period, when the flower thrips, upon which they mostly feed, have left the trees.

INTERNAL PARASITES.

Thus far no internal parasites have been found attacking the citrus thrips. Although the Chalcid parasite of Thysanoptera (*Thripoctenus russelli* Crawf.)[2] has been found by the writer in the San Joaquin Valley affecting the bean thrips (*Heliothrips fasciatus* Perg.) and the flower thrips (*Frankliniella tritici* Fitch.), for some

[1] Identified by Otto Heideman.

[2] This parasite was first reared from *Heliothrips fasciatus* Perg. by H. M. Russell (see U. S. Dept. Agr., Bur. Ent., Tech. Ser. Bul. 23, pt. 2, Apr. 27, 1912). It was described as a new genus and species by J. C. Crawford in 1911 (see Proc. Ent. Soc. Wash., vol. 13, p. 233, 1911).

reason it does not attack the citrus thrips, although the close association of this thrips with the bean thrips on orange trees seems to be a good reason why it should do so, and it is quite possible, seemingly, that the citrus thrips may in the future become one of its hosts.

SPIDERS.

A large number of spiders, representing three or four families, capture the citrus thrips as a part of their food. The most important of these in the matter of destroying citrus thrips is a small gray spider belonging to the family Dictynidae, genus Dictynus.[1] The Dictynidæ are tubeweavers, and this particular species commonly spins a thin sheet of web irregularly across an orange leaf, in a single one of which adult and larval citrus thrips have often been counted to the number of 50 or more. It is rare to find a web of one of these young spiders with less than from 5 to 10 thrips entangled in its meshes. The little spiders have several times been seen with the thrips in their jaws.

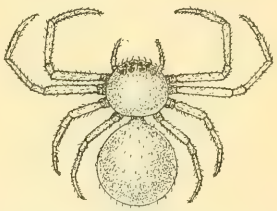


FIG. 9.—Young spider, *Misumessus* sp., which preys upon the citrus thrips. (Original.)

The second most important Arachnid enemy of the citrus thrips is one of the jumping spiders (Fam. Salticidae), known as *Thiodina puerperis*. This spider is very active in seizing its prey, which it pounces upon cat fashion. From 4 to 10 or more thrips will be eaten in succession by one of these young spiders. The spider drains the juice from the body of its victim and casts the skeleton aside.

Another spider (fig. 9), belonging to the genus Misumessus, has often been taken in its immature stages with the citrus thrips in its possession. This spider is a yellowish, very active creature belonging to the family of so-called crab spiders (Thomisidae). It is commonly found, solitary, upon orange leaves. It does not spin a web.

A small black spider (*Erigone* sp.), less common on orange trees than any of the foregoing, is sometimes seen with adult citrus thrips in its possession. As is the case with all the foregoing thrips enemies, insects and spiders alike, except the 6-spotted thrips, this spider feeds upon thrips when it is young, but confines itself mostly to larger insects after it has become mature. The young, actually about one-twentieth inch long, is shown greatly magnified in figure 10.

FUNGUS GROWTH ATTACKING THRIPS.

The spores of an unidentified fungus have occasionally been seen about the bodies of citrus thrips which have died in captivity, but it seems probable that either this fungus attached the insects after

[1] All spiders referred to herein have been identified by Nathan Banks.

death or the attack resulted from the excessive moisture formed in the rearing jar by the orange leaves. It results only from abnormal conditions and is plainly unimportant in the field.

IMPORTANCE OF NATURAL AGENCIES IN CONTROLLING THE THRIPS.

The citrus thrips appears to be subject to controlling influences the nature of which is difficult to determine completely. The most severe infestation recorded against the insect occurred in Tulare County in 1909, when 90 per cent of the entire crop of navel oranges of that county was thrips marked, and close to 20 per cent of it was so badly scarred and distorted that it was unsalable at a profitable price. In 1910 the insects failed to appear in anything like their numbers of 1909 and the injury was less than 50 per cent of what it had been during that season. This naturally affected the results due to spraying by the growers in 1910, even where the work was done thoroughly, as in many cases unsprayed fruit was injured so slightly that the difference in returns between sprayed and unsprayed fruit was so small that very little profit was derived from the operation. In 1911, thrips were still less numerous and more scattered early in the season and it looked as though the injury would be very slight. Owing, however, to an unusually backward season, in which the trees made but slow and scanty growth, the insects were forced to depend to a greater extent than usual on the fruit for food, on which they concentrated in the latter part of the season. The marking was late in appearing, but at the end of the season proved to be somewhat more extensive than in 1910. This illustrates the fact that the abundance of thrips is not always a reliable index of the extent of expected damage to the fruit.

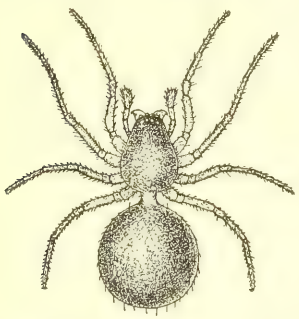


FIG. 10.—Immature spider, *Erigone* sp., which preys largely upon the citrus thrips. (Original.)

The chief factors influencing the decrease of thrips subsequent to 1909 are undoubtedly the climatic changes and relative inadequacy of the food supply. In 1910 and 1911 the late, cold spring was the cause of the slowness with which the insects increased during April, May, and June; while the same climatic condition, in retarding the growth of the trees, further checked the increase of the insects by reducing their food. Furthermore, it forced the insects to scatter widely over many food plants, thus hindering reproduction and greatly retarding oviposition by causing dearth of suitable plant tissue.

CONTROL EXPERIMENTS.

PLAN OF SPRAYING EXPERIMENTS IN 1911.

The principal experiments in 1911 were conducted in an orange orchard about 2 miles east of Lindsay, Cal., and about the same distance from the nearest foothills, lying between the latter and the town. A supplementary set of experiments was conducted in an orchard situated on the slope of the foothills about 2 miles from the first orchard, the object being to test out practically the same sprays under different conditions. The trees of the latter orchard were younger than those of the former, and, as is true of most foothill groves, worse thrips infested. The insecticides used in the two sets of experiments are listed below, Series I referring to the valley orchard and Series II to the foothills orchard. A further experiment, in which 2,550 Valencia and Joppa and a number of navel nursery trees were sprayed, was conducted in a third orchard about 2 miles from the foothills.

Series I: Valley ranch.

Plat No. 1. Unsprayed, check.
2. Lime-sulphur solution (36° Baumé), 1–28.
3. Lime-sulphur solution (36° Baumé), 1–56.
4. Unsprayed, check.
5. Tobacco extract (40 per cent nicotine sulphate), 1–800.
6. Tobacco extract (40 per cent nicotine sulphate), 1–1,600.
7. Unsprayed, check
8. Lime-sulphur solution (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–800.
9. Lime-sulphur solution (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
10. Lime-sulphur solution (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–2,400.
11. Cresol soap, 1–500, and tobacco extract (40 per cent nicotine sulphate), 1–800.
12. Cresol soap, 1–500, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
13. Unsprayed, check.
14. Fish-oil soap, 1–250, and tobacco extract (40 per cent nicotine sulphate), 1–800.
15. Fish-oil soap, 1–250, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
16. Sulphur-soda solution,[1] 1–25.

[1] The sulphur-soda solution (plats 16 and 17) was prepared as follows:

Powdered sulphur	pounds	30
Powdered caustic soda (98 per cent)	do	15
Water to make	gallons	30

The sulphur was made into a paste with water and the soda added, while the mixture was constantly stirred, in sufficient quantity to cause boiling, a little water being added occasionally to retard the cooking. When all the sulphur was dissolved, enough cold water was added to make a stock solution of 30 gallons. A clear, amber liquid, much resembling good lime-sulphur, was the result.

Plat No. 17. Sulphur-soda solution, 2–25.
18. Resin wash,[1] 1–3.
19. Resin wash, 1–5.
20. Resin wash, 1–10.
21. Plain water.
22. Unsprayed, check.

Each of the foregoing plats of Series I consisted of two rows of 25 trees each, or 50 trees to the plat. The trees were 18-year-old Washington navels, and the entire experimental block was bordered on two sides by trees of the same kind and planting, and on the remaining sides by Valencias and a road, respectively.

Series II: Foothills ranch.

Plat No. 1. Lime-sulphur solution (33° Baumé), 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–150.
2. Lime-sulphur solution (33° Baumé), 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–100.
3. Tobacco extract (2¾ per cent nicotine sulphate), 1–100.
4. Tobacco extract (40 per cent nicotine sulphate), 1–1,600.
5. Tobacco extract (40 per cent nicotine sulphate), 1–2,400.
6. Tobacco extract (40 per cent nicotine sulphate), 1–1,600, and cresol soap, 1–400.
7. Tobacco extract (40 per cent nicotine sulphate), 1–2,400, and cresol soap, 1–400.
8. Plain water.
9. Unsprayed, check.
10. Tobacco extract (40 per cent nicotine sulphate), 1–800.
11. Tobacco extract (40 per cent nicotine sulphate), 1–1,600, and fish-oil soap, 1–200.
12. Tobacco extract (40 per cent nicotine sulphate), 1–2,400, and fish-oil soap, 1–200.

Plats 1 to 8 of Series II consisted of 4 rows of 28 trees each; plat 9, of 5 rows of 28 trees; the remaining plats, of 2 rows of 28 trees each. All trees were 4-year-old Washington navels. The only lime-sulphur available for use unmixed in Series II was a quantity which had been exposed to the air for a year. It was used, with misgivings, and the results, which are omitted as of no value, proved conclusively that it had lost most of its insecticidal power.

[1] The stock resin wash (plats 18, 19, and 20) was made fresh for each application, as follows:

Resin	pounds	20. 0
Caustic soda (98 per cent)	do	3. 6
Fish oil	pints	3. 0
Water enough to make	gallons	50. 0

All the ingredients were placed in a 60-gallon iron kettle with 10 or 15 gallons of water and brought to boiling. Melting was aided by constant stirring. Hot water was added occasionally until the mixture had boiled constantly for about 1½ hours and had reached 50 gallons.

NURSERY-SPRAYING EXPERIMENTS.

Plat No. 1. 2,550 Valencia and Joppa orange trees, sprayed with lime-sulphur, 1–50.

2. Several thousand Washington navel orange trees, sprayed with lime-sulphur, 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–150.

Time and number of applications.—Three applications of the insecticides were made at the valley ranch, Series I, with the object of saving the fruit from injury. Owing to a very cold and backward season and the age of the trees, growth was scant and the first application was not necessary until June 2. The second application was timed principally to catch adult thrips which had transferred to the fruit and larvæ which had issued from it since the first application and was started June 17. The third application was timed solely by the abundance of thrips on the fruit and was begun July 8.

The first application at the foothills ranch, Series II, was started May 15, and the second June 6, both about a week later than was intended, owing to failure of the ranch foreman to produce sprayer, teams, and labor promptly when requested, the writer being dependent upon the grower for these items by agreement. The difference in the time of the first application between the valley ranch, Series I, and the foothills ranch, Series II, indicates approximately the difference between the two localities in the time when the petals dropped and the thrips began to feed on the fruit.

The nursery trees were sprayed June 7, July 15, and August 31; the sprayings were timed solely by the abundance of thrips.

RESULTS FROM SPRAYING.

The determination of the relative value of the different insecticides and of spraying is based solely upon the effectiveness of the work in raising the commercial grade of the fruit. These grades represent money values, and their improvement, which was the primary object of the investigation, thus effects a tangible saving. The qualities determining the grading of oranges were studied out at the various packing houses, and in this work the writer received the willing cooperation of the managers of most of the packing houses at Lindsay, Cal. As the fruit from the experiments of Series I was graded under a different system from that of Series II, it will be necessary to state the results of each series of experiments in terms of the commercial grading of the fruit from that series.

RESULTS IN SERIES I.

The results of the spraying experiments at the valley ranch are summarized in Tables VII and VIII. The comparatively slight infestation in this orchard in 1911 is evident from the figures for the unsprayed plats, Nos. 1, 4, 7, 13, and 22, in Table VII. The variation in the percentage of fruit injured sufficiently to reduce the grade

in the different check plats shows the uncertainty of the infestation and the necessity, in order to obtain reliable comparison, of several interspersed lots of unsprayed trees. The comparisons would be still more accurate if it had been feasible to leave single untreated trees interspersed among the sprayed trees of each plat, but the work of keeping the fruit from a large number of scattered trees in 17 plats separate for examination would involve too much time and expense, and there would be much risk of the pickers, paid by the box, mixing the fruit.

TABLE VII.—*Comparison of fruit sprayed for the citrus thrips with that unsprayed, Series I, Lindsay, Cal., 1911.*

No. of plat.	Treatment of trees.	Amount of fruit examined.		Commercial grading of fruit.			
		Number of loose boxes.	Number of oranges.	Number of first-grade oranges.	Number of second-grade oranges.	Per cent first-grade oranges.	Per cent second-grade oranges.
1	Untreated	20	2,386	1,981	405	83.1	16.8
2	Lime-sulphur (36° Baumé), 1–28	20	2,308	2,285	23	98.9	1
3	Lime-sulphur (36° Baumé), 1–56	20	2,243	2,225	18	99.1	.8
4	Untreated	20	2,180	1,734	446	79.4	20.4
5	Tobacco extract (40 per cent nicotine sulphate), 1–800	20	2,300	2,247	53	97.5	2.3
6	Tobacco extract (40 per cent nicotine sulphate), 1–1,600	20	2,281	2,160	121	94.6	5.1
7	Untreated	20	2,442	2,188	254	89.5	10.4
8	Lime-sulphur (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–800	20	2,337	2,272	65	97.1	2.7
9	Lime-sulphur (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–1,600	20	2,420	2,321	99	95.8	4
10	Lime-sulphur (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–2,400	20	2,387	2,174	213	91	8.8
11	Cresol soap, 1–500, and tobacco extract, 1–1,600	20	2,345	2,071	274	88.2	11.6
12	Cresol soap, 1–500, and tobacco extract (40 per cent nicotine sulphate), 1—2,400	20	2,126	1,740	386	81.8	18.1
13	Untreated	20	2,648	1,878	770	70.8	29
14	Fish-oil soap, 1–250, and tobacco extract (40 per cent nicotine sulphate), 1–800	20	2,555	2,299	256	89.8	10
15	Fish-oil soap, 1–250, and tobacco extract (40 per cent nicotine sulphate), 1–1,600	20	2,444	2,041	403	83.4	16.4
16	Sulphur-soda, 1–25	20	2,563	2,294	269	89.4	10.4
17	Sulphur-soda, 2–25	20	2,622	2,510	112	95.7	4.1
18	Resin wash, 1–3	20	2,700	(1)	(1)	(1)	(1)
19	Resin wash, 1–5	20	2,760	(2)	(2)	(2)	(2)
20	Resin wash, 1–10	20	2,596	(3)	(3)	(3)	(3)
21	Plain water	20	2,639	2,191	448	82.9	16.9
22	Untreated	20	2,650	2,176	474	82	17.8

[1] 83.6 per cent of fruit injured by spray.
[2] 69.6 per cent of fruit injured by spray.
[3] 43.7 per cent of fruit injured by spray.

The fruit from plats 1 and 4 was considered as one unsprayed lot for comparison with the sprayed fruit from plats 2 and 3; that from plats 4 and 7 as a check on the same from plats 5 and 6, etc., in order to get unsprayed fruit as nearly as possible representative of what sprayed fruit would have been without treatment. More than

95 per cent of the grade reduction occurring in the orchard was caused by thrips injury. The efficacy of the various insecticides in raising the grade of the fruit is shown in Table VIII.

TABLE VIII.—*Efficacy of the spray mixtures in Series I.*

Unsprayed fruit.			Sprayed fruit.			
Plat No.	Number of boxes first-grade fruit.	Number of boxes low-grade fruit.	Plat No.	Number of boxes first-grade fruit.	Number of boxes low-grade fruit.	Grade-raising efficacy of the sprays.
						Per cent.
1 and 4.	81	19	2	99	1	95
			3	99	1	95
4 and 7.	85	15	5	98	2	87
			6	95	5	67
7and 13.	80	20	8	97	3	85
			9	96	4	80
			10	91	9	55
			11	88	12	40
			12	82	18	10
13 and 22.	79	21	14	90	10	52
			15	84	16	24
			16	90	10	52
			17	96	4	81
			21	83	17	19

The relative worth of the spray mixtures in Series I, as indicated in Tables VII and VIII, may be summarized as follows:

1. From 80 to 90 per cent grade-reducing injury prevented by—
   Lime-sulphur (36° Baumé), 1–28.
   Lime-sulphur (36° Baumé), 1–56.
   Tobacco extract (nicotine sulphate 40 per cent), 1–800.
   Lime-sulphur (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–800 and 1–1,600.
   Sulphur-soda solution, 2–25.
2. Between 60 and 80 per cent of injury prevented by—
   Tobacco extract (40 per cent nicotine sulphate), 1–1,600.
3. From 50 to 60 per cent of injury prevented by—
   Lime-sulphur (36° Baumé), 1–86, and tobacco extract (40 per cent nicotine sulphate), 1–2,400.
   Fish-oil soap, 1–250, and tobacco extract (40 per cent nicotine sulphate), 1–800.
   Sulphur-soda solution, 1–25.
4. Less than 50 per cent of injury prevented by—
   Cresol soap, 1–500, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
   Fish-oil soap, 1–500, and tobacco extract (40 per cent nicotine sulphate), 1–2,400.
   Fish oil soap, 1–250, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
   Plain water.
5. Fruit and leaves severely injured by—
   Resin wash, 1–3; 1–5; and 1–10.

Contrary to expectation, the addition of soaps to tobacco solutions did not appear to increase their efficacy, but, on the contrary, seemed to lower it. Straight tobacco extract with 40 per cent nicotine sulphate,

diluted 1–800 and 1–1,600, respectively, gave better results than at the same strengths with the addition of soaps. This fact is difficult to account for, but may be due partly to more severe infestation of the trees on which the soap was used than on those sprayed with the unmodified tobacco extracts. The soap plats were located two on either side of check plat 13, in which there was 29 per cent of low-grade fruit; but the comparison is made with the average between plats 13 and 22, in which there was 21 per cent low-grade fruit. The infestation may have been as severe in the soap plats as in check plat 13. The plats treated with straight tobacco extracts lay between check plats 4 and 7, with only 20 and 5 per cent low-grade fruit, respectively. The foregoing explanation does not hold, however, for the similar results from soap and tobacco extracts, under different conditions, in Series II, and the latter experiments seem to lend further weight to the probability that but little benefit will result from adding soaps to tobacco extracts as sprays for the citrus thrips. Experiments under very heavy and uniform thrips infestation, however, might result somewhat differently.

RESULTS IN SERIES II.

The fruit from the experimental plats in Series II was packed in three commercial grades instead of two, as was that of Series I. The results from spraying are given in percentage of fruit of each of the three grades, from all the separate plats, in Table IX.

TABLE IX.—*Comparison of fruit sprayed for the citrus thrips with that unsprayed, Series II, Lindsay, Cal., 1911.*

Plat No.	Treatment of trees.	Amount of fruit examined.		Commercial grading of fruit.		
		Number of boxes.	Number of oranges.	Per cent first-grade fruit.	Per cent second-grade fruit.	Per cent third-grade fruit.
1	Lime-sulphur (33° Baumé), 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–150	20	2,492	40.3	51.8	7.8
2	Lime-sulphur (33° Baumé), 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–100	20	2,504	46	44.4	9.4
3	Tobacco extract (2¾ per cent nicotine sulphate), 1–100	20	2,371	25.7	53.1	21
4	Tobacco extract (40 per cent nicotine sulphate), 1–1,600	20	2,502	33	46.6	20.2
5	Tobacco extract (40 per cent nicotine sulphate), 1–2,400	20	2,711	19.2	54	26.7
6	Cresol soap, 1–400, and tobacco extract (40 per cent nicotine sulphate), 1–1,600	20	2,336	30.2	48.3	21.3
7	Cresol soap, 1–400, and tobacco extract, 1–2,400	20	2,403	22.2	52.8	24.7
8	Plain water	20	2,582	7.4	46.7	45.7
9	Untreated	20	2,271	6.7	52	41.1
10	Tobacco extract (40 per cent nicotine sulphate), 1–800	20	2,176	42	47.6	10.2
11	Fish-oil soap, 1–200, and tobacco extract, (40 per cent nicotine sulphate), 1–1,600	20	2,147	30	51.3	18.6
12	Fish-oil soap, 1–200, and tobacco extract, (40 per cent nicotine sulphate), 1–2,400	20	2,049	27.4	50.7	21.8

The relative worth of the spray mixtures in this series may be divided roughly into four groups, according to their relative merits, as follows:

1. Sprays raising about three-fourths of the injured fruit from third to first grade:
   - Lime-sulphur (33° Baumé), 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–150.
   - Lime-sulphur (33° Baumé), 1–75, and tobacco extract (2¾ per cent nicotine sulphate), 1–100.
   - Tobacco extract (40 per cent nicotine sulphate, 1–800.
2. Sprays raising about one-half the injured fruit from third to first grade:
   - Tobacco extract (2¾ per cent nicotine sulphate), 1–100.
   - Tobacco extract (40 per cent nicotine sulphate), 1–1,600.
   - Cresol soap, 1–400, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
   - Fish-oil soap, 1–200, and tobacco extract (40 per cent nicotine sulphate), 1–1,600.
   - Fish-oil soap, 1–200, and tobacco extract (40 per cent nicotine sulphate), 1–2,400.
3. Sprays raising about one-third of the injured fruit from third to first grade:
   - Tobacco extract (40 per cent nicotine sulphate), 1–2,400.
   - Cresol soap, 1–400, and tobacco extract (40 per cent nicotine sulphate), 1–2,400.
4. Without insecticidal value:
   - Plain water at high pressure.

As indicated by the figures in Table IX, insecticides in the first of the foregoing groups raised from 31 to 33 per cent out of a probable 41 per cent of third-grade fruit to first grade; i. e., over three-fourths of it; those in the second group, only about 20 per cent, or about half of it; and those in the third group prevented only about one-third of the injury.

The results from the more effective sprays in Series II may be stated in terms of the gross receipts of the fruit. The difference in price per box between the grades for this particular fruit was as follows: First-grade fruit brought 67 cents more per box than third-grade and 29 cents more than second grade, which brought 38 cents more than third-grade fruit. The differences in receipts per hundred boxes between sprayed plats 1, 2, and 10 and the check plat are given below:

Plat 1.—33.3 boxes raised from third grade to first grade, at 67 cents	$22.31
0.2 boxes raised from second grade to first grade, at 29 cents	.06
Amount received per 100 boxes sprayed fruit in excess of the unsprayed	22.37
Plat 2.—31.7 boxes raised from third grade to first grade, at 67 cents	21.23
7.6 boxes raised from second grade to first grade, at 29 cents	2.20
Amount received per 100 boxes sprayed fruit in excess of unsprayed	23.43

Plat 10.—30.9 boxes raised from third grade to first grade, at 67 cents	$20.70
4.4 boxes raised from second grade to first grade, at 29 cents per box	1.27
Amount received per 100 boxes sprayed fruit in excess of unsprayed	21.97

Taking into consideration the fact that only two early applications were made in Series II, at the foothills ranch, it will be seen that in seasons like 1911, when the infestations are light, reasonably successful commercial spraying may be depended upon to insure an increase of at least 25 cents for every box of sprayed fruit over the unsprayed fruit.

RESULTS IN NURSERY SPRAYING EXPERIMENTS.

That portion of the nursery designated as Plat 1 was sprayed thoroughly with a gasoline-power outfit used in orchard work. The trees in Plat 2 were given equally careful treatment, being well drenched each time, but the spraying was done with a small, hand-power outfit, fitted with a nozzle of the Vermorel type. The results from the use of the gasoline-power outfit were greatly superior to those from the hand-power outfit, demonstrating the greater efficiency of the former. In October the trees sprayed with the gas-engine outfit looked so remarkably clean and vigorous that they attracted attention; at this time they had a good growth of about 3 feet, without curled leaves and with but little of the whitish discoloration characteristic of thrips injury to leaves. On the trees sprayed with the hand-power outfit the proportionate growth was somewhat less and thrips marking was noticeably more severe.

CONCLUSIONS FROM SPRAYING TESTS.

In the foregoing two sets of tests the following insecticides and combinations gave the best results. Any of these mixtures may be relied upon to give satisfactory control when properly applied.

1. *Lime-sulphur solution.*—If the lime-sulphur is of a density of 36° Baumé, dilute 1 gallon with 56 gallons of water; if of a density of 33° Baumé, dilute 1 gallon with 50 gallons of water.

2. *Sulphur-soda solution.*—Two gallons of the stock solution, prepared as described on page 29, diluted with 25 gallons of water.

3. *Lime-sulphur and tobacco extract (40 per cent nicotine sulphate).*—Dilute 1 part of the lime-sulphur, if 34 to 36° Baumé, with 86 parts of water; if 30 to 33° Baumé, with 75 parts of water. Then add 1 part of the tobacco extract to 1,000 parts of the lime-sulphur as diluted above.

4. *Tobacco extract (40 per cent nicotine sulphate).*—Dilute 1 part with 800 parts of water.

Lime-sulphur and soda-sulphur solutions are more effective against the citrus thrips than any other mixture thus far tested, and particularly the lime-sulphur at the strength stated above. A large per-

centage of the thrips can be killed by spraying with this solution, and there is a further effectiveness due to its decomposition for a long period after deposition on the leaves. In orchards sprayed with good lime-sulphur the sulphurous odor is often strong for two months or more after the applications. The decomposition products repel the thrips, which are slower to reinfest orchards so sprayed than those sprayed with solutions that soon evaporate and leave no trace.

Tobacco extracts when used at the proper strengths are also very effective. Both tobacco extract and lime-sulphur, when mixed together, are effective in weaker solutions than when diluted with water alone. Contrary to expectation, the addition of soaps to tobacco extract did not give increased value to the tobacco in these tests. Soap solutions used alone appear to be worthless at the dilutions tested.

Resin wash at any strength practicable for use on the orange trees in this section is worthless. At the greatest strength used in these experiments it failed to reduce thrips injury to an extent worthy of attention. It is, furthermore, very injurious to fruit and foliage.

Plain water spraying was utterly ineffective, demonstrating that merely striking the thrips with a liquid at high pressure to wash them from the trees has no appreciable effect in diminishing their numbers. A few hours after spraying with water there remained on the trees as many living, active thrips as before spraying.

INJURIES TO CITRUS RESULTING FROM SPRAYING.

INJURY FROM DISTILLATE-OIL EMULSION.

In experiments conducted in 1910, emulsions containing 2 per cent of distillate oil caused severe staining to ripe oranges. Dark streaks were formed on the rind where the liquid had collected in drops and run down. A patent spray emulsion caused more staining than the home product at the same strength.

INJURY FROM RESIN WASH.

On July 20, 1911, about two weeks after the final spray application, injury appeared from the resin wash in plat 18, Series I. About 3 per cent of the leaves had turned brown and fallen and most of the oranges had become spotted with the varnish. In some cases the varnish had collected in drops and run down over the surface, finally drying to a hard, gummy substance. By September 25 the injury apparently had reached its highest degree and was serious in all three plats, though noticeably decreasing with the greater dilution of the wash. The epidermal cells of fruit protected from the direct rays of the sun were killed and a shallow, brown scab was formed. This scab often peeled off, leaving a film of light gray-green tissue

beneath. Where the liquid collected in large drops it formed a thick amber to black scab which did not slough off readily. The injury was most severe in places previously injured by thrips.

INJURY FROM LIME-SULPHER.

A small percentage of the fruit sprayed with lime-sulphur mixture diluted 1–28 (Series I, plat 2) developed in the rind slight hardened depressions resembling burns or scalds. Such injury occurred largely in spots previously injured by thrips, and in one case in a katydid scar. Less than 2 per cent of the fruit was spray-injured even by this strength of solution. In plat 3 (lime-sulphur 1–56) not more than one-half of 1 per cent of the exposed fruit was slightly injured in similar fashion.

In a special test on four orange trees, using lime-sulphur at the rate of 1 gallon to 15 gallons water and making the applications on the hottest days of the summer, very severe injury developed. By the first of June some of the fruit developed severe blisters, or hard, puffy, excrescences of the rind, and a small amount of the fruit fell to the ground. Unlike the injury from resin wash, that from the strong lime-sulphur soon attained its severest degree and was always most severe on oranges exposed to the direct rays of the sun, particularly the afternoon sun. It was also particularly severe in places where the fruit had been bruised or where it had been injured by insects. By fall, from 18 to 25 per cent of the fruit had developed spray injury, the average for all four trees being 21 per cent.

Lime-sulphur is harmless to fruit or leaves when used weaker than 1 part to 28 parts water. It has a remarkably stimulating effect upon the leaf growth of orange trees. In all plats where lime-sulphur was used, no matter what the dilution, the trees sprayed with it produced a growth of foliage much in excess of that produced by their unsprayed neighbors.

SUMMARY OF RECOMMENDATIONS FOR CONTROLLING THE CITRUS THRIPS.

SPRAY MIXTURE AND TIME OF APPLICATION.

Plain lime-sulphur solution, 1 to 56 of the 36° Baumé density or 1 to 50 of the 33° Baumé, is recommended as the most reliable of the four best mixtures resulting from the tests.

The thrips first occur in injurious numbers at the same time that the navel orange blossoms drop most of their petals; they transfer from the leaves to the fruit gradually as the petals fall. The first spray application therefore should be made when four-fifths or more of the petals have fallen. This will check the thrips at a time when the orange is most susceptible of deep injury. The exact date for the application can not be given, as the period when the petals fall and the thrips transfer to the fruit will be as much as 30 days later in some seasons than in others, depending on the spring weather.

The second application should be timed to prevent injury both from larvæ issuing from the very young fruits and from adults emerging from the pupal stage existent at the time of the first application. This renewed attack may be expected to reach the danger point in from 10 to 14 days after the first spraying. The second spraying should not be delayed too long, as comparatively few larvæ may, by constantly feeding in a circle about the base of the fruit, cause deep ring scarring. Special effort should be made to drench only the fruit and the remaining tender leaves.

The third application may be delayed longer if the first two have been thorough and well timed. It generally takes the insects from three to four weeks to become dangerously numerous again, as they reinfest the sprayed trees much more slowly after the second spraying.

All three applications should be completed by the time the fruit is half grown, after which it rapidly loses its attractiveness for the insects, which then find it necessary to spread out over the comparatively scant tender orange growth and miscellaneous food plants.

During the latter part of August and early in September there is usually another abundant growth of orange shoots, and upon this the thrips congregate in large numbers. A fourth application during this period is advisable in some seasons to prevent severe injury to this growth, which is often the most abundant of the season.

The first spray application to nursery stock should be made when thrips become numerous on the spring growth and before their injury becomes very evident, usually between April 15 and May 15. In the case of trees budded in the fall the shoots springing from the original stock should be cut back the following spring as soon as the bud has attained a good growth. All the prunings should be burned to destroy contained eggs and larvæ. In Tulare County this pruning and burning usually can be accomplished during April. The growing scions must then be watched closely and as soon as thrips occur in numbers spraying should begin. From two to four further applications should follow the first spraying, depending upon the number of growths and the degree of infestation.

SUGGESTIONS FOR SPRAYING.

The gasoline-power outfit, by reason of its large nozzle capacity, reliability, and comparatively low cost of operation, is recommended for spraying bearing orchards, young orchards in excess of 10 acres, and large nurseries. Hand-power outfits, when of a type capable of maintaining a pressure of not less than 125 pounds, are suitable for spraying seed-bed and nursery stock and young orchards of small acreage.

The spraying outfit should be in perfect running order not later than April 1, with the insecticide materials at hand and conveniently

located near the water supply and as near as possible to the trees to be sprayed. Supplies should be ordered not later than the January or February preceding the spraying operations.

HOW TO SPRAY BEARING ORCHARDS.

It is best to use only two 50-foot leads of hose on a power outfit, with 10-foot rods each fitted with a Y which is angled to handle two nozzles. The latter should be of the larger chamber type, with disks bored to one-sixteenth inch. Each rodman should begin at about the middle of a tree, on the side away from the sprayer, and work around the tree until he reaches the starting point; he should then switch to the same point on the next tree without shutting off the nozzles and with as much economy of movement as possible.

The nozzles should be held about 2 feet from the tree so that the broad portion of the stream plays upon fruit and leaves. The trees should be swept from tip to base, special attention being given to the fruit and the tender growth, where the insects congregate. The pressure, if maintained at 150 to 200 pounds, will turn the leaves and whirl the little fruits so that all sides will be sprayed.

No attempt should be made to spray too many trees with a single outfit, and an application once commenced should be completed within 10 days. Nursery and young orchard trees will require from $\frac{1}{2}$ gallon to 2 gallons of the dilute spray each; those from 5 to 10 years old should be given not less than 5 gallons each; and those from 12 to 18 years old not less than 8 gallons each.

HOW TO SPRAY NURSERIES AND YOUNG TREES.

For large nurseries the gas-engine outfit, where it can be advantageously used, is preferable to the hand outfit. Two 25-foot or even 15-foot leads of hose and 12-foot spray rods are generally most convenient for this work, though the equipment of hose and rods recommended for orchard work will answer very well. The excess hose length should be coiled over a peg fastened to the spray tank or engine hood, so that the young trees will not be injured by the dragging hose. In setting out a nursery it is preferable to leave driveways wide enough to accommodate sprayer and team at intervals of eight rows (where the rows are 4 feet apart) throughout the length of the bed; for example, one between the fourth and fifth rows, and again between the twelfth and thirteenth, etc. Eight rows of trees, four either side of the driveway, may then be reached each trip, using 12-foot spray rods; eight more rows may be taken on the return trip, etc. Either the large chamber type or the single Bordeaux nozzles may be used to good advantage, but the delivery of the spray need not be so rapid as for orchard work. The trees will need attention only when the growth is tender.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 617

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER September 23, 1919

AUSTRALIAN SALTBUSH.

By Roland McKee, *Assistant Agrostologist, Office of Forage-Crop Investigations.*

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EARLY TESTS OF THE AUSTRALIAN SALTBUSH.

The Australian saltbush (*Atriplex semibaccata*) was introduced into the United States some 25 years ago and was distributed more or less generally throughout the arid and semiarid regions. The very high hopes held at that time regarding its prospective value have not been realized. Except in California and Arizona the plantings resulted in failure, and in those States under cultivation it is unable to compete with more productive crops, like alfalfa and beans. In early trials in California it did quite well and was so reported by the State experiment station writers and others. The early plantings in Arizona resulted in failure and only with the development of irrigation has it become well established in that State. For a number of years, and especially between the years 1900 and 1910, Australian saltbush seed was grown by the California experimental substation, located at Tulare, and by Mr. Guy E. Heaton, of Paso Robles, Calif. The seed grown at these places was distributed gratis or sold through commercial channels, and the larger part was probably planted on the arid range lands of the Southwest.

Except in California, plantings made on the range lands were failures, and in general the use of this saltbush for range purposes was not considered a success. However, some of the plantings along the

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coastal region about Los Angeles and San Diego seem to have done exceptionally well, and from these plantings it promptly escaped, spreading over range lands and waste places throughout the coastal area and islands from the Mexican border on the south to the Salinas Valley on the north. There it constitutes a real asset, providing pasturage at a season when most other forage plants are dormant. While the actual outcome of the introduction of Australian saltbush is very different from early high hopes and predictions, the facts justify the conclusion that its introduction has proved a benefit to those areas where it has become naturalized.

DESCRIPTION OF THE PLANT.[1]

The Australian saltbush is a semiwoody, prostrate perennial, forming a dense mass 6 to 12 inches thick. (Fig. 1.) The leaves are

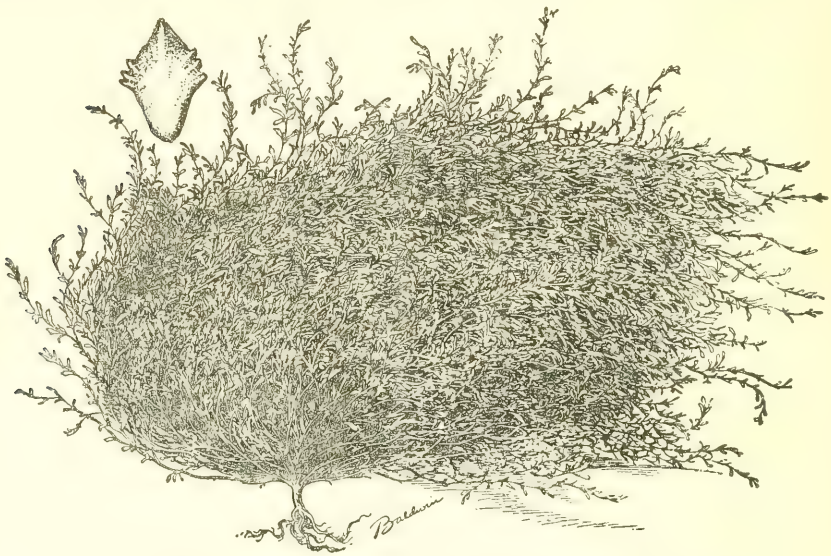

FIG. 1.—A plant of Australian saltbush (*Atriplex semibaccata*) grown in a grass garden.

linear, 1 inch long, and coarsely toothed along the margins. The seed is small and inclosed in a pair of fleshy foliaceous bracts which become red as the fruit matures. The plants are perhaps long-lived

[1] In newspapers and popular magazines, the Rosy saltbush (*Atriplex rosea*) has been confused with the Australian saltbush (*Atriplex semibaccata*). Rosy saltbush is an annual, native to Europe, and much resembles in appearance and habits the common tumbleweed. In the last 15 years it has spread with great rapidity over nearly all of the semiarid States. It prefers alkaline soil, but spreads as a weed on all farm lands, much as does the Russian thistle. In the East it is a rather rare weed in waste places and appeared in New York and New Jersey as early as 1879. In the West it was found in Wyoming in 1897 and in Oregon and Washington in 1901. Since then it has spread over most of the area west of the one hundredth meridian and in many places is found in such great abundance as to be a troublesome weed. While this plant is usually considered as a weed only, it has some merit, as have most weeds. Sheep and other stock will browse it when other and better feed is not available, but it is no better than tumbleweed or Russian thistle in this respect. While it has some value as forage, it probably does not possess sufficient merit to justify any one in purposely planting it on his farm.

perennials, but under some conditions they live but two or three years. Near Paso Robles, Calif., where they have been grown under cultivation, the growth is strong and vigorous the first year, becomes much weakened in the second year, and after that the plants soon succumb. (Fig. 2.) In this particular locality this saltbush has not become aggressive, and while a few plants have escaped from cultivation, they are weak and spindling and do not show the usual vigor of plants under cultivation the first year. While there are no definite

FIG. 2.—The Australian saltbush grown under cultivation in a young apple orchard at Paso Robles, Calif.

records as to the length of life of these plants in favorable regions, such as Los Angeles and San Diego, from general appearances it would seem that they live for a number of years.

DISTRIBUTION.

The Australian saltbush has become naturalized, that is, fully established, only in California and Arizona. In California it is confined to the coastal region south of San Francisco and to the irrigated districts of the Imperial Valley and the upper San Joaquin Valley, centering about Tulare and Bakersfield. In Arizona it is found in the agricultural areas of the Salt River Valley about Phoenix, in the Santa Cruz Valley about Tucson, and in the Yuma Valley near Yuma. The northern limit where this saltbush has been observed is Hollister, Calif., about 100 miles south of San Francisco. In this district it occurs in small quantity, and while it makes a very luxuriant growth it does not develop seed in such abundance as farther south. In the Salinas Valley, Calif., it is found all the way from Salinas to some distance beyond Soledad. It is not abundant in this valley, but the plants make a vigorous growth and develop a heavy

crop of seed. It is probable that this saltbush has been but recently introduced into the Salinas Valley, which may account for its lack of abundance at present.

The climatic and other conditions in the coastal region in California seem to be especially favorable to the Australian saltbush, and it is found almost everywhere from Santa Barbara to San Diego. (Fig. 3.) It generally extends inland a distance of 10 to 15 miles, but is found in small quantities at much greater distances. At Highlands, which is about 45 miles from the coast and due east of Los Angeles, it occurs in considerable quantity and is doing well. At Corona, which is about 25 miles from the coast, it is found in abundance.

From general observations it would seem that the Australian saltbush is confined to areas with somewhat favorable soil-moisture conditions. On the extremely dry areas, on the lower levels as well

FIG. 3.—The Australian saltbush growing along a roadside fence near San Diego, Calif.

as at higher elevations, it is not found. Along the immediate coast in the fog belt it does extremely well, which apparently is due to the fact that the fog supplies the moisture essential to its growth. While the present distribution of this saltbush is confined almost exclusively to the lower altitudes, it occurs in small quantity at an altitude of 1,800 feet near Alpine, Calif., and at 1,400 feet near Ramona, Calif. It is probable that temperature and moisture conditions rather than altitude determine the limits of growth of this plant; however, observations on this point are very limited.

In the upper San Joaquin Valley the Australian saltbush occurs in abundance, but its distribution in this region is confined to irrigated or semi-irrigated lands. For some miles west of Bakersfield and extending northwest of Wasco and east to Famosa it is found in practically

all cultivated fields and along roadsides, and it grows luxuriantly in irrigated alfalfa fields both on the levees or ridges and in the borders or checks throughout the fields. About Tulare it does not do so well as in the Bakersfield-Wasco area. However, it appears in considerable quantity on the higher ground along fences and on well-raised ridges in irrigated fields. The lands about Tulare are low, poorly drained, and quite wet during the winter. Apparently this wet condition is the factor that limited the spread of this saltbush in this area.

In Arizona the Australian saltbush is largely confined to the irrigated areas, where it is found growing along ditch banks, roadsides, and in neglected fields.

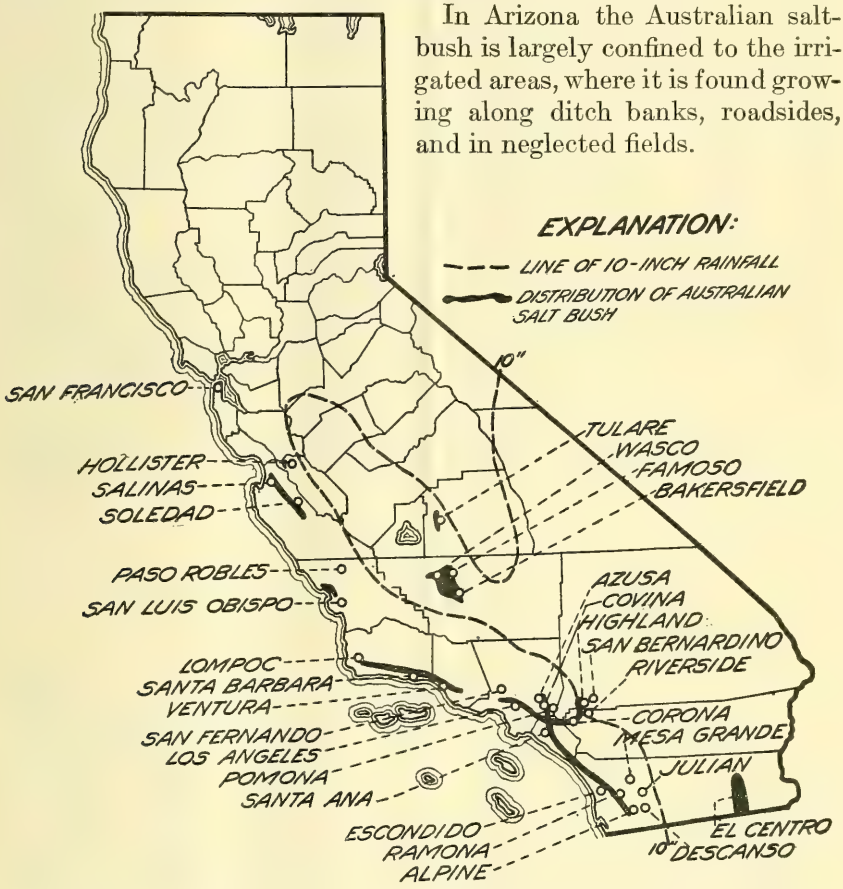

FIG. 4.—Outline map of California, showing the distribution of the Australian saltbush.

The accompanying map shows the present distribution of the Australian saltbush in California, as far as known. (Fig. 4.)

CLIMATIC REQUIREMENTS.

The climatological record of various places in the Australian saltbush area of California and Arizona is given in Table I. The maximum temperature recorded is 118° F., at Yuma, Ariz. At Bakersfield, Calif., and at Phoenix and Tucson, Ariz., where high tempera-

tures are recorded, this saltbush grows luxuriantly. Along the coast, where high temperatures are seldom recorded, it does equally well. The minimum temperature recorded at any place in California or Arizona where it is known to be growing at the present time is 10° F., at Tucson, Ariz.

The mean annual precipitation at places in California where the Australian saltbush is growing well without irrigation ranges from 9 to 19 inches. This saltbush thrives about San Diego, where the mean annual precipitation is about 9 inches. Here, however, fogs make the conditions favorable, and plants no doubt do well with much less precipitation than would be the case inland. At Santa Barbara, where the mean annual precipitation is 16.6 inches, this saltbush grows luxuriantly, but it does not occur in as great abundance as about San Diego and Los Angeles. At Santa Cruz, where the mean annual precipitation is 27 inches, and about San Francisco Bay, where the mean annual precipitation is 22.5 inches, it is not found. Whether or not this is due to the heavier precipitation is not certain. It may be partly due to generally cooler weather, as the mean annual temperature at these places is lower than at points farther south where this saltbush does well. The mean annual temperature in regions where it is more abundant is about 60°. However, at Salinas, where it is growing quite vigorously, the mean annual temperature is about 56° F., which is the same as at San Francisco and 2 degrees lower than at Santa Cruz.

TABLE I.—*Climatological record for various places in the saltbush area of Arizona and California.*

[Data from Bulletins Q and L, Weather Bureau, U. S. Department of Agriculture.]

State and place of observation.	Temperature (° F.).			Mean annual precipitation.
	Mean annual.	Maximum.	Minimum.	
				Inches.
California:				
San Diego	61	101	32	9.4
Los Angeles	62	109	28	15.6
Santa Barbara	60	100	28	16.6
San Luis Obispo	59	106	22	19.2
Santa Cruz	58	108	22	27.0
San Francisco	56	100	29	22.5
Hollister	59	105	19	12.3
San Jose	58	104	18	14.8
Salinas	56	95	20	14.12
Soledad				8.97
Kings City	58	114	15	10.8
Redlands	64	113	25	14.7
Riverside	62.9			10.01
Fresno	63	114	20	9.2
Tulare				7.65
Bakersfield	66	114	19	4.8
Mojave	65.5	114	15	4.79
Arizona:				
Yuma	72.0	118	22	2.7
Phoenix	70.0	116	22	6.8
Tucson	68.0	112	10	9.8

SOIL REQUIREMENTS.

While the Australian saltbush has been noted as growing on practically all types of soil, it occurs in but few regions where the soil does not contain a greater or less amount of alkali. Table II presents the analysis of various soils in which it was found growing. It is to be noted that the salt content ranges from nothing to 2.61 per cent of the dry weight. This saltbush is quite tolerant of alkali, and will thrive in soils that will grow but very few ordinary crops.

DROUGHT RESISTANCE.

The Australian saltbush is quite drought resistant, but apparently not to the extent of some other species of Atriplex and many desert plants. Table II gives the moisture content for the summer or rainless season of various soils at San Diego, Calif., in which saltbushes were well established. The minimum moisture content was 1.51 per cent for the first 6 inches of soil and 1.75 per cent for the first 12 inches. In soils with such low moisture content the plant apparently can make no growth, but the fact that it exists under such conditions and resumes growth when favorable conditions prevail entitles it to be designated as drought resistant.

TABLE II.—*Sodium-chlorid content of the Australian saltbush and of the soil in California in which it was found growing.*

[Analyses made by J. F. Breazeale; soil samples taken at San Diego, Calif., Aug. 23 and Sept. 4, 1918.]

Soil sample.				Soil moisture (per cent).	NaCl content (per cent).	
No.	Location.	Weight (gramr).			Soil.	Dry plant.
		Initial.	Dry.			
1	90 feet from high tide				0.104	7.01
2	120 feet from edge of salt flat				.035	8.17
3	Salt flat, at edge of seepage				.435	8.17
4	Edge of bay, moistened at high tide				1.710	16.34
5	Mesa, near Sweetwater dam (first 6 inches of soil)	269.0	265.0	1.51	.030	8.40
6	Levee, 3 feet above water level				.047	13.05
	Depression by levee, moist and alkaline:					
7	Topsoil				1.110	15.66
8	Subsoil				1.110	
9	Salt flat, a little above water level				2.610	23.20
10	Dry soil, near Ramona	267.1	262.5	1.75	.020	4.64
	Dry gravelly ridge, at Chula Vista:					
11	First foot	250.7	237.3	5.65	0	8.70
12	Second foot	297.1	272.1	9.19		
13	Third foot (8 inches)	191.5	176.0	8.80		
	Dry level spot not cultivated for 3 years:					
14	First foot	250.6	239.5	4.63		
15	Second foot	312.3	293.0	6.58		
16	Third foot	356.8	330.0	8.12		
	Paso Robles				.06	.87

In the extremely dry areas where the annual precipitation is low and the surface soils usually dry, as in the Bakersfield and Mojave regions, the Australian saltbush does not occur. However, in these regions

a number of other desert plants, including other species of Atriplex, are found in abundance. The absence of this saltbush in these regions is perhaps due in part to the fact that considerable humidity and surface soil moisture are essential for the germination of the seed and growth of the young plant, and such conditions seldom exist at any period of the year in the regions mentioned.

ANALYSES OF THE PLANT.

In Tables II and III are given analyses of the tops or stems and leaves of Australian saltbush plants. In Table II only the sodium-chlorid content is shown. An attempt has been made to correlate the sodium-chlorid content of the plant with the sodium-chlorid content of the soil in which it was growing. It will be noted that the plants containing the greatest percentage of sodium chlorid were grown in the soil having the greatest percentage of this substance. This relation, however, does not always hold true, for some of the soils with low sodium-chlorid content produce plants high in this substance; but in general there seems to be a positive correlation between soils with high sodium-chlorid content and plants high in this compound.

The analyses given in Table III show that saltbush forage has a comparatively high content of protein and of nitrogen-free extract and crude fat. These data, however, are not indicative of its feeding value, as the high sodium-chlorid content has to be taken into consideration.

TABLE III.—*Composition of the Australian saltbush compared with that of alfalfa.*

[From Farmers' Bulletin 108, p. 15.]

Material.	Constituents (per cent).					
	Moisture.	Ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Crude fat.
Green stems and leaves:						
Australian saltbush	78.03	4.58	2.75	3.75	10.41	0.48
Alfalfa	75.04	1.80	4.91	6.34	11.09	.86
Hay samples:						
Australian saltbush	7.05	19.37	11.64	15.88	44.05	2.01
Alfalfa	10.95	6.43	17.60	22.63	39.31	3.08

VALUE FOR PASTURE.

In regions to which it is adapted the Australian saltbush is quite aggressive and this characteristic makes it more valuable for pasture purposes. It grows readily from seed and is distributed by the seed being carried in various ways from place to place. The introduction of this saltbush into new localities has followed the traveled highways, railroads, and overland trails.

On account of its high salt content the Australian saltbush is not as palatable as most ordinary forage, but it is eaten readily by sheep, goats, cattle, and horses when other forage is scarce. By reason of its nonpalatability it is avoided early in the season when other forage is plentiful, and thus is available in a green state later in the summer when most other plants have become entirely dry. Its ability to furnish succulent feed which serves as a reserve supply in late summer seems to constitute the real value of this plant. It is not sufficiently drought resistant to grow in areas where other and better forage plants will not succeed, and for this reason its use must be confined to the more favorable regions where it will serve as a reserve supply in late summer, as already indicated.

To be of the greatest value the Australian saltbush must be supplemented with other feeds. If fed alone stock will eat it only in limited quantities on account of its high salt content, and for the same reason when eaten in large quantity it is more or less injurious to animals.

SEEDING ON RANGE LANDS.

There is but little information regarding the best practice in seeding the Australian saltbush on pasture and range lands. However, in view of the fact that under natural conditions the seed ripens in the fall and drops to the ground soon afterward, it would seem that fall seeding may well be practiced. It is possible that spring seeding may give good results under conditions where weeds or competing plants are not abundant, but where winter-growing annuals have already made a good growth and summer annuals are beginning growth it is not likely that this saltbush will have much chance to establish itself.

The only thing that can be done economically is to scatter the seed broadcast in favorable locations and allow it to take care of itself. If it will not grow and reseed itself under such conditions it can not be used profitably for range purposes.

SEEDING UNDER CULTIVATION.

In growing the Australian saltbush under cultivation the best time for seeding is in the spring, about the time that corn ordinarily would be planted. The land should be well prepared, as for any other small-seeded crop, by plowing and subsequent harrowings. Care should be taken to cover the seed very shallow. Seed planted deep will not germinate, and for this reason it is necessary to have good moisture conditions at the surface, so that shallow-planted seed will receive enough moisture to insure germination. The planting should be made in rows about 3½ feet apart, and cultivation should be given as for any ordinary field crop planted in rows.

HARVESTING FOR SOILING.

The Australian saltbush makes a fair soiling crop, and for this purpose it can be cut at any time after the plants have made sufficient growth to warrant handling. The plants remain green and hold their leaves late in the season, and consequently it can be used in the fall as well as early. The saltbush handled in this way is eaten quite readily by stock, but for the best results it should be fed with other forage and, if possible, supplemented with grain feed.

On account of the plants being very prostrate they can not be cut with an ordinary mowing machine unless some device is attached for lifting the stems. However, it is probable that one would want to feed saltbush in this way only in very limited quantities or for very short periods, and under such conditions it could be cut with an ordinary scythe.

HARVESTING FOR SEED.

The seed of the Australian saltbush drops from the plant very readily as soon as it is ripe, and for this reason it can not be cut and handled for seed like most other crops. The best method of procedure in harvesting the seed is to place a piece of canvas about 6 by 3 feet in dimensions under the plants and then knock the seed off with a stick or flail. This method is somewhat slow, but there seems to be no easier way of harvesting this seed. After the seed has been knocked from the plants it should be spread on a large canvas to dry. On account of the moisture contained in the pulpy bracts inclosing the seed it can not be put immediately in sacks or in large piles without heating. After it has been dried it can be sacked and stored like any other seed. The seed of this saltbush ripens in the latter part of August and through September. It does not ripen all at once, so that one must determine when a maximum of seed is ready to harvest. Under favorable conditions about 300 pounds of seed can be secured from an acre.

VALUE FOR HAY.

The Australian saltbush possesses but little value for hay. The stems are too woody for this purpose, and on account of the plants being very prostrate the handling at best would be quite expensive.

DISEASES.

A diseased condition of plants of *Atriplex semibaccata* was noted as occurring quite commonly in the Los Angeles and San Diego region. These diseased plants presented a blackened or sooty appearance, with the tops or upper stems and leaves most severely affected. Specimens collected at Chula Vista, Calif., on September 4, 1918, were presented to Miss Vera K. Charles, who has identified

the organisms causing this condition as *Macrosporium commune* Rabh. and *Cladosporium herbarum* (Pers.) Link. These, she states, are not known to occur except as saprophytes. As the plants on which these fungi were found are not in a dead or abnormal condition except in the parts where these fungi occur, it seems probable that insect injury, sun scald, or some other destructive agency preceded the fungi.

SUMMARY.

The Australian saltbush was introduced throughout the semiarid regions of the United States some 25 years ago. In practically all cases the plantings resulted in failure, and only along the coast and in the San Joaquin and Imperial Valleys of California and in the Salt River, Yuma, and Santa Cruz Valleys of Arizona has it become well established.

The plant is perennial and prostrate, forming a dense mass from 6 to 12 inches thick.

The minimum temperature of any region in which it is naturalized is 19° F. The mean annual precipitation of regions in which it is growing successfully without irrigation ranges from 9 to 16 inches.

While the Australian saltbush has been noted as growing on practically all types of soil, it is found in but few regions where the soil does not contain an appreciable amount of alkali.

It is quite drought resistant, but apparently not to the extent of some other species of Atriplex and other desert plants.

Chemical analyses of the leaves and stems of the Australian saltbush show that they have an unusually high content of common salt and comparatively large percentages of protein, nitrogen-free extract, and crude fat.

In regions to which it is adapted the Australian saltbush is quite aggressive, and this characteristic adds to its value as a range plant.

On account of its high salt content, it is not as palatable as most ordinary forages, but it is eaten readily by sheep, goats, cattle, and horses when other feed is scarce. To be of greatest value it must be supplemented with other feeds.

The greatest value of the plant is to supply succulent feed in late summer and to furnish a reserve supply. It can be used as a soiling crop, but has little value as hay.

Seed is produced freely, but harvesting is expensive. For range purposes Australian saltbush seed should be sown in the fall. The only thing that can be done economically is to scatter the seed broadcast in favorable locations and allow it to take care of itself.

In seeding for growing under cultivation, care should be taken to cover the seed only enough to insure moisture conditions favorable for germination.

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Rhodes Grass. (Farmers' Bulletin 1048.)
Certain Desert Plants as Emergency Stock Feed. (Department Bulletin 728.)

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 618

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER March 13, 1918

EXPERIMENTS WITH DURUM WHEAT.

By CARLETON R. BALL, *Agronomist in Charge*, and J. ALLEN CLARK, *Scientific Assistant, Western Wheat Investigations, Office of Cereal Investigations.*

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INTRODUCTION.

Extensive experiments with the durum wheats have been conducted in this country for the last 10 to 15 years. During this period their commercial importance has increased steadily. At first they were regarded commercially with indifference, then with hostility, and finally with approval. Numerous bulletins have discussed their introduction and adaptation and also their value under more or less limited conditions. These publications are listed alphabetically by authors at the end of this bulletin.

The purpose of the present bulletin is to assemble the principal accumulated experimental data on yields of durum wheat in the United States. Many of these data are here published for the first time. Some of them, however, have been published previously in the bulletins cited. The bibliography also includes citations of bulletins containing some results obtained with durum wheat which are not presented here. This bulletin discusses the history of durum wheat in the United States, the statistics of production, the characters and relationships of the important varieties, and the results of experiments conducted at 30 field stations.

SOURCES OF DATA.

The experimental data have been derived from three chief sources, namely, experiments conducted cooperatively by the Bureau of Plant Industry and State agricultural experiment stations, experi-

ments conducted independently by the Bureau of Plant Industry, and, finally, to make the record more complete, experiments conducted independently by various States.[1]

For convenience of discussion the stations from which the data published herein have been obtained are arranged, in the list which follows, in three groups located, respectively, in the subhumid Prairie States, in the semiarid Plains States, and in the arid basins and valleys of the Far West.

Of the data from stations in the subhumid Prairie States, those from McPherson, Kans.; Ames, Iowa; Brookings, S. Dak.; and Fargo, N. Dak., were obtained cooperatively, and those from Manhattan, Kans.; Lincoln, Nebr.; Ashland, Wis.; and St. Paul and Crookston, Minn., were obtained independently by the State experiment stations.

In the Great Plains area data from the following stations were obtained in cooperation with the State experiment stations: Hays, Kans.; Highmore, Eureka, and Newell, S. Dak.; Dickinson and Williston, N. Dak.; and Moccasin, Mont. At Archer, Wyo., the cooperation is with the Wyoming State Board of Farm Commissioners. At Amarillo, Tex., and Akron, Colo., the data were obtained independently by the Bureau of Plant Industry. At Amarillo the Office of Cereal Investigations conducts the station in cooperation with the Amarillo Chamber of Commerce. At Akron the Office of Dry-Land Agriculture conducts the station, and the Office of Cereal Investigations cooperates in the experiments with cereals. At North Platte, Nebr.; Edgeley and Langdon, N. Dak.; Brandon, Manitoba; and Indian Head, Saskatchewan, the data were obtained independently by the State experiment stations or the Canadian Department of Agriculture.

Of the six stations in the basin and valley areas of the Far West, five were conducted cooperatively, namely, Nephi, Utah; Aberdeen, Idaho; Burns and Moro, Oreg.; and Modesto, Cal. The sixth, at Chico, Cal., is conducted by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, with which the Office of Cereal Investigations cooperates in the cereal experiments.

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[1] The sources of the data from the stations conducted independently by the various States are indicated at the proper points in the text. The men who have been in charge of the cereal experiments during part or all of the years cited, at stations where experiments have been conducted either independently or cooperatively by the Office of Cereal Investigations, Bureau of Plant Industry, are listed as follows: *California.*—Chico, E. L. Adams; Modesto, H. F. Blanchard. *Colorado.*—Akron, W. G. Shelley, Clyde McKee, C. H. Clark, and George A. McMurdo. *Idaho.*—Aberdeen, L. C. Aicher. *Iowa.*—Ames, L. C. Burnett. *Kansas.*—Hays, J. G. Haney, O. H. Elling, A. M. Ten Eyck, C. C. Cunningham, and F. A. Kiene, jr.; McPherson, V. L. Cory. *Montana.*—Moccasin, E. L. Adams and N. C. Donaldson. *North Dakota.*—Dickinson, L. R. Waldron, C. H. Clark, J. A. Clark, and R. W. Smith; Fargo, J. H. Shepperd and O. O. Churchill; Williston, F. R. Babcock. *Oregon.*—Burns, L. R. Breithaupt; Moro, H. J. C. Umberger and D. E. Stephens. *South Dakota.*—Brookings, J. S. Cole, Clifford Willis, and M. J. Champlin; Eureka, M. J. Champlin; Highmore, M. J. Champlin and J. D. Morrison; Newell, Cecil Salmon and J. H. Martin. *Texas.*—Amarillo, A. H. Leidigh and J. F. Ross. *Utah.*—Nephi, F. D. Farrell, P. V. Cardon, A. D. Ellison, and J. W. Jones. *Wyoming.*—Archer, J. W. Jones and V. H. Florell.

The writers gladly acknowledge here the effective cooperation of the several State experiment stations in the conduct of experiments and the courtesy of the directors and their associates, who have furnished data obtained independently by their stations.

HISTORY.

Durum wheat, though a comparatively recent immigrant in the United States, has long been grown extensively in other parts of the world. Southern Russia is the principal producing area. Large quantities are grown also in the Mediterranean region, especially in Italy, France, and Algeria. Smaller quantities are produced in India and in South America, particularly in Argentina and Chile. In Russia the crop is spring sown, but in most of the Mediterranean region, with its mild climate, the crop is sown in autumn.

The first official introduction of durum wheat varieties occurred apparently in 1853. In that year a durum variety, called Algerian Flint (Browne, 1855),[1] was obtained from the Province of Oran in Algeria, and another, called Turkish Flint (Browne, 1855, 1856), from near Mount Olympus, in Asia. The Mount Olympus of modern maps is in European Turkey, not far from Saloniki. The Turkish Flint was described as a black-glumed variety. It was grown to some extent in various parts of the eastern United States and later became known as Mount Olympus and as Olympia wheat (Klippart, 1858). In 1854 a durum variety distributed as Syrian Spring was obtained in Palestine (Browne, 1855), supposedly near Mount Carmel. It appears not to have become cultivated to any appreciable extent. In 1864 an introduction of Arnautka (Reid, 1866) was made, presumably from Russia, and grown in 1865 with other varieties on what are now the grounds of the Department of Agriculture near Fourteenth Street, Washington, D. C. None of these introductions became established as a farm crop.

The next recorded official introduction was made in 1899 (Carleton, 1900, p. 11), followed by still others in the next two or three years. These last-named introductions, from which the crop was really established, were made by Mr. M. A. Carleton, Cerealist of the United States Department of Agriculture. In 1898–1899 and again in 1900 he went to Russia and Siberia for the purpose of obtaining adapted cereal crops. Chief among these introductions was durum wheat, of several varieties, particularly Kubanka.

Introductions of durum wheat had been made by Russian settlers in several States of the Great Plains area and its culture established locally. Additional introductions have also been made by other representatives of the Department of Agriculture and the State

[1] Reference is made to name and date in the "Bibliography," p. 61–64.

experiment stations. However, a strenuous campaign of education led by Mr. Carleton was necessary to fix the commercial status of durum wheat, after which it soon became a staple American crop.

In the meantime deficiencies in the supply of European durum wheat and the activities of Duluth wheat exporters enabled the macaroni manufacturers of the Mediterranean countries to become acquainted with American durum wheat. An export outlet was obtained in this way, which aided greatly in giving the crop some standing among farmers while its commercial status in this country was being established.

Several difficulties were met in the process of establishing the growing of durum wheats on a commercial basis in this country. Chief of these was the fact that there was no market demand for these wheats in America. Macaroni, spaghetti, and other manufactured forms of durum wheat were not generally used, and durum flour was unknown. The durum wheats were an unknown quantity to the grain trade, the milling industry, and the eaters of bread. The kernels were different in size, color, and hardness from those of other wheats grown here and so could not be thrown into the established grades or mixed in granaries, cars, or elevators. They were so hard that mills could not grind them with the equipment and methods then in use, and few millers thought they could afford to spend the time and money for necessary experiments. Much opposition arose, therefore, and the price of durum wheat was depressed below that of common wheat. For the first few years almost no market existed.

Figure 1 shows graphically the comparative market value of No 1 Durum and No. 1 Northern wheat at Duluth, Minn., in the 15 years from 1902 to 1916, inclusive. The value given is the closing price on the first business day of each month during that period.

From this diagram it will be noted that the average spread in price in the nine years from 1902 to 1910, inclusive, was about 15 cents per bushel in favor of common wheat. At the country elevators the discrimination against durum, especially in small lots, frequently was as much as 25 cents per bushel. Under these market conditions much durum wheat was fed to stock on the farms where it was grown.

During 1911 the spread in price gradually decreased, and in the last five years, 1912 to 1916, inclusive, the average price has been about the same. During part of this period the price of durum has been appreciably above that of common wheat.

It must be recalled that the figures for market value at Duluth are always more favorable to durum wheat than those from any other point. Durum wheat which has arrived at Duluth not only is in commercial channels, but often is already en route to an export mar-

ket, presumably in response to a definite demand. At other terminals, and especially back at the primary markets, as noted above, conditions were much less favorable to this wheat.

AGRONOMIC ADAPTATION AND PRODUCTION.

Durum wheat owes its importance in this country to certain characters which adapt it to the conditions prevailing in parts of the spring-wheat belt.

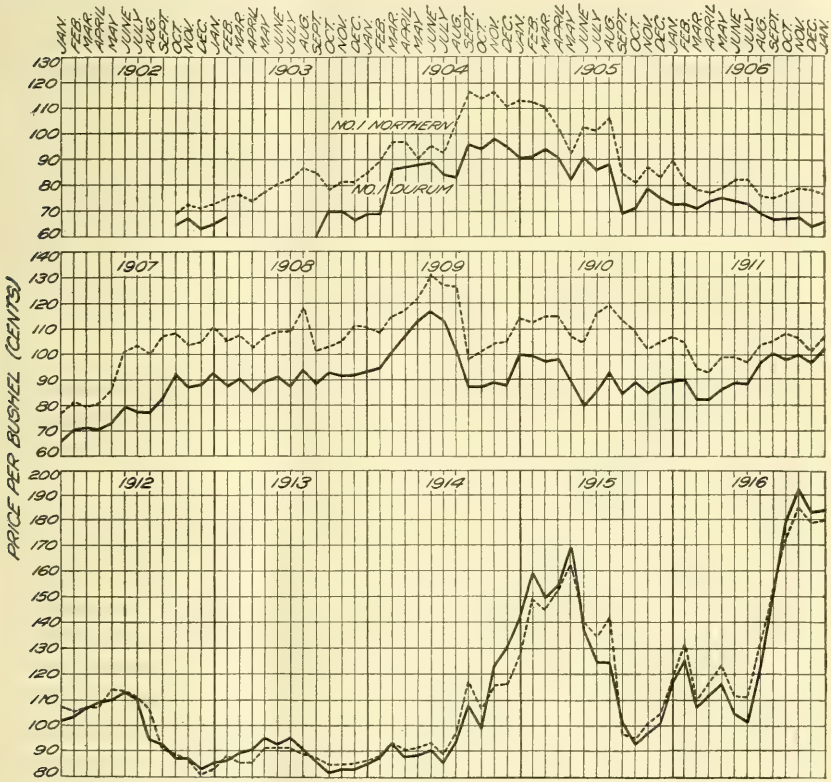

FIG. 1.—Diagram showing the prices of No. 1 Durum wheat and No. 1 Northern wheat at Duluth, Minn., on the first day of each month in the 15 years from 1902 to 1916, inclusive.

ADAPTATION.

The characters which have given the durum wheats their outstanding agricultural value are resistance to, or evasion of, drought and rust. Some of the factors involved are rapid and vigorous growth, fairly early maturity, and some measure of actual resistance to drought and the attacks of rust. Under certain climatic conditions the combination results in a uniformly higher yield than that of any varieties of common wheat.

The durum varieties certainly tolerate or withstand drought to a much greater degree than common wheats. This has given them their widespread popularity in the western half of the northern Great

Plains. An apparent exception to this high-yielding power under drought conditions was noted at several stations in the two very dry years, 1910 and 1911. In these years the durum wheats produced relatively low yields. This was found to be due, however, not to lack of drought resistance, but to sterility caused by a combination of climatic conditions, including drought and hot winds coincident with the flowering period of durum wheat. The floral organs were injured, and the kernels did not develop, much reducing the yields. On some of the same stations durum wheat which was sown later in the spring and had not reached the flowering stage at the time hot winds occurred was not injured, although exposed to all the other drought conditions.

Many varieties of durum wheat are somewhat resistant, and certain varieties very resistant, to attacks of stem rust (*Puccinia graminis* Pers.). The varieties now grown commercially are subject to more or less infection on the sheaths and leaves, while the peduncle, or neck, often remains fairly free from such infection. This allows the development of a fairly plump kernel under rust conditions which cause serious injury to the common wheats.

The durum wheats also are less subject to smut than the spring common wheats. Bunt, or stinking smut (*Tilletia foetens* (B. and C.) Trel. and *T. tritici* (Beij.) Wint.), rarely affects durum wheat, although the loose smut (*Ustilago tritici* (Pers.) Rost.) occurs about as frequently on durum as on common wheats.

There are some objections to the growing of durum wheat, wholly apart from market considerations. The long stiff beards are such a source of discomfort in handling the crop that many farmers object to growing it on that account. However, the increasing use of machinery in harvesting and thrashing is gradually removing this objection. The spike or head in the durum wheats is so compact that it dries very slowly after rains or heavy dews. This makes the durum varieties susceptible to the attacks of scab (*Fusarium culmorum* (W. Sm.) Sacc.) and other imperfect fungi. These fungi sometimes affect durum wheat rather seriously.

The durum wheats have come from countries of low rainfall and fairly high summer temperatures, where loss of moisture by evaporation is rapid. The results of many experiments show them to be valuable under similar conditions in the northern Great Plains in this country. On account of their ability to produce well in the presence of rust infection, they also are valuable and widely grown in the subhumid portions of the Dakotas and western Minnesota.

PRODUCTION.

The varieties of durum wheat introduced by the United States Department of Agriculture in the years 1898 to 1900 were distributed to farmers as well as to experiment stations. The new introductions soon became popular among farmers of the northern Great Plains.

Among the varieties distributed, the Kubanka and Arnautka proved to be well adapted.

Production increased rapidly during the early years. It rose from 60,000 or 70,000 bushels in 1901 to about 6,000,000 or 7,000,000 bushels in 1903, and probably about 50,000,000 bushels by 1906. As noted in the discussion of its history, the development of the market did not keep pace with the increased production. For this reason the price, which had always been less than that of common wheat, dropped to even lower levels, the difference sometimes amounting to 20 or 25 cents a bushel. This low price so discouraged the growers that the production in 1909 was slightly less than 40,000,000 bushels.

The census figures, taken for the crop year 1909, show that 87½ per cent of the durum wheat produced in the United States that

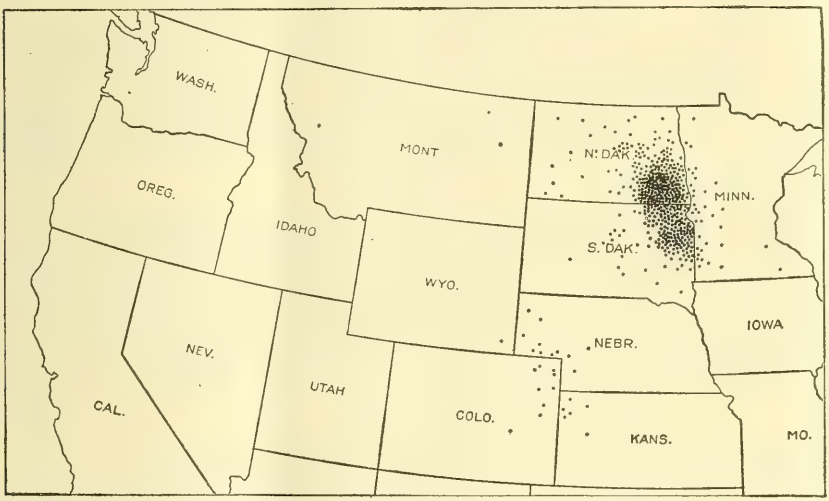

FIG. 2.—Outline map of the northwestern United States, showing the acreage of durum wheat in 1909. Each dot represents 5,000 acres. (Data from the Thirteenth U. S. Census.)

year was grown in North Dakota and South Dakota. Minnesota ranked third in production, with about 7 per cent of the total crop, and practically all of the remaining 5 or 6 per cent was grown in Nebraska, Kansas, Colorado, Wyoming, and Montana. Figure 2 is an outline map of the northwestern United States, illustrating the production of durum wheat in 1909.

Since 1909 the Bureau of Crop Estimates of the United States Department of Agriculture has gathered annual data upon the acreage and production of durum wheat in the three States of Minnesota, North Dakota, and South Dakota. In 1915 Montana was added. Table I shows the estimated annual production of durum wheat and of all other wheats and the percentage of durum in the total wheat production in the three States named during the eight years from 1909 to 1916, inclusive.

TABLE I.—*Estimated annual production of durum and of all other wheats and the percentage of durum in the total wheat production in Minnesota, North Dakota, and South Dakota in the eight years from 1909 to 1916, inclusive.*[1]

[Production expressed in thousands of bushels (000 omitted).]

State and kind of wheat.	1909	1910	1911	1912	1913	1914	1915	1916	8-year average.
Minnesota:									
Durum wheat	2,810	2,624	1,494	2,334	1,692	990	1,400	613	1,745
Other wheat	54,284	61,376	42,441	64,704	66,348	41,985	72,020	26,942	53,763
Percentage of durum in total	4.9	4.1	3.4	3.5	2.5	2.3	1.9	2.6	3.1
North Dakota:									
Durum wheat	19,176	6,276	11,126	17,884	10,302	10,389	22,000	7,275	13,054
Other wheat	97,606	32,224	62,074	125,936	68,553	71,203	129,970	32,050	77,452
Percentage of durum in total	16.4	16.3	15.2	12.4	13.1	12.7	14.5	18.5	14.4
South Dakota:									
Durum wheat	15,845	15,231	3,404	14,343	9,535	6,724	14,500	2,999	10,323
Other wheat	31,215	31,489	11,396	37,842	24,440	24,842	49,262	21,826	29,039
Percentage of durum in total	33.7	32.6	23.0	27.5	28.1	21.3	22.8	12.1	26.2
Total of all three States:									
Durum wheat	37,831	24,131	16,024	34,561	21,529	18,103	37,900	10,887	25,121
Other wheat	183,105	125,089	115,911	228,482	159,341	138,040	251,252	80,818	160,225
Percentage of durum in total	17.1	16.2	12.1	13.1	11.9	11.6	13.1	11.9	13.6

[1] These figures are estimates made in the Bureau of Crop Estimates of the United States Department of Agriculture, except for 1909, for which year they are taken from the Thirteenth Census.

In 1909 the total production was 39,958,947 bushels. In 1910 and 1911 the production was reduced by severe drought to about 24,000,000 and 16,000,000 bushels, respectively. With a short crop

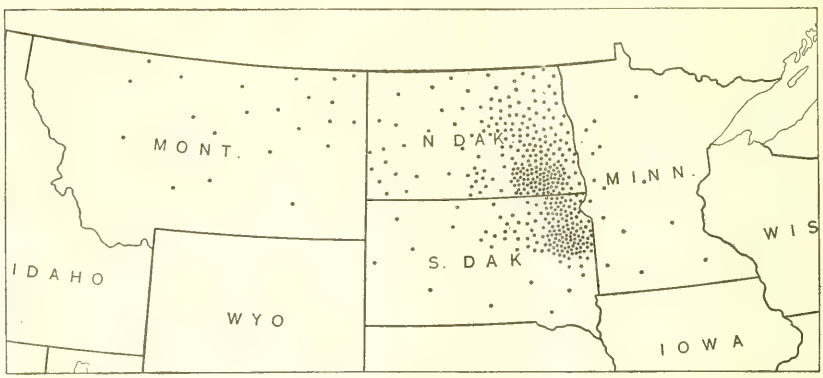

FIG. 3.—Outline map showing the acreage of durum wheat in 1915 in the States of Minnesota, North Dakota, South Dakota, and Montana. Each dot represents 5,000 acres. (Data from the Bureau of Crop Estimates, United States Department of Agriculture.)

and increasing demand, durum prices became about equal to those of common wheat. In 1912 the production was again increased to slightly less than 40,000,000 bushels, the price remaining equal to that

of other wheats. Production was reduced again during the years 1913 and 1914. This smaller production was responsible in part for the higher price which was obtained for the crop during these years. In 1915 production increased sharply in response to the stimulus of good prices and increasing demand. Since the fall of 1911, as noted previously, the price of durum wheat usually has been equal to or slightly better than that obtained for common spring wheats. (See fig. 1.) Several causes have contributed to this. Among them are (1) better facilities for milling these hard wheats, (2) increasing use for making macaroni in this country, and (3) increasing export demand. Figure 3 is a map showing the production of durum wheat in Minnesota, South Dakota, North Dakota, and Montana in 1915, according to the figures of the Bureau of Crop Estimates.

DESCRIPTION AND KEY.

In the genus Triticum, durum wheat has been regarded as one of the seven or eight species or subspecies. The writers are not concerned with its taxonomic status at this time, but merely with those characters which mark the durum wheats as distinct from the common wheats.

DESCRIPTION.

Durum wheat differs from common wheat in the characters of both plant and kernel. The durum plant usually is taller (fig. 4) and more vigorous than that of common wheat varieties; the culms are thicker and the leaves broader. The spikes average broader and shorter (see fig. 9) than those of common wheat and are much more compact. In some varieties they are so short and broad as to be veritable club wheats.

The crowding of the spikelets on the rachis, together with the large size of the kernel, results in a characteristic outcurving or expansion of the spikelet which widens the spike on both sides of the rachis. As a result, the spike is flattened transversely to the plane of the rachis or to the plane of the face of the spikelets (fig. 5) instead of parallel with it, as in the case of common wheat.

The awns of durum wheat are much longer than those of any variety of common wheat. They vary in length from 1 to 2½ decimeters or more. The long, stiff awns and the compact head give the plant much the appearance of barley, for which it is often mistaken by those not familiar with the crop.

The kernels of durum wheat are larger than those of common wheat (fig. 6), varying from about 7 to 10 mm. in length, with an average length of 8 to 8½ mm. As the name indicates, the kernels are very hard, the endosperm being entirely corneous. The seed coats are unpigmented. The effect of the completely corneous endosperm and unpigmented seed coats is a kernel of a clear amber appearance,

FIG. 4.—Plants of four hard spring wheats, representing durum wheat and three groups of common wheat: *a*, Kubanka (durum); *b*, Fife (Rysting); *c*, Preston; *d*, Bluestem (Haynes).

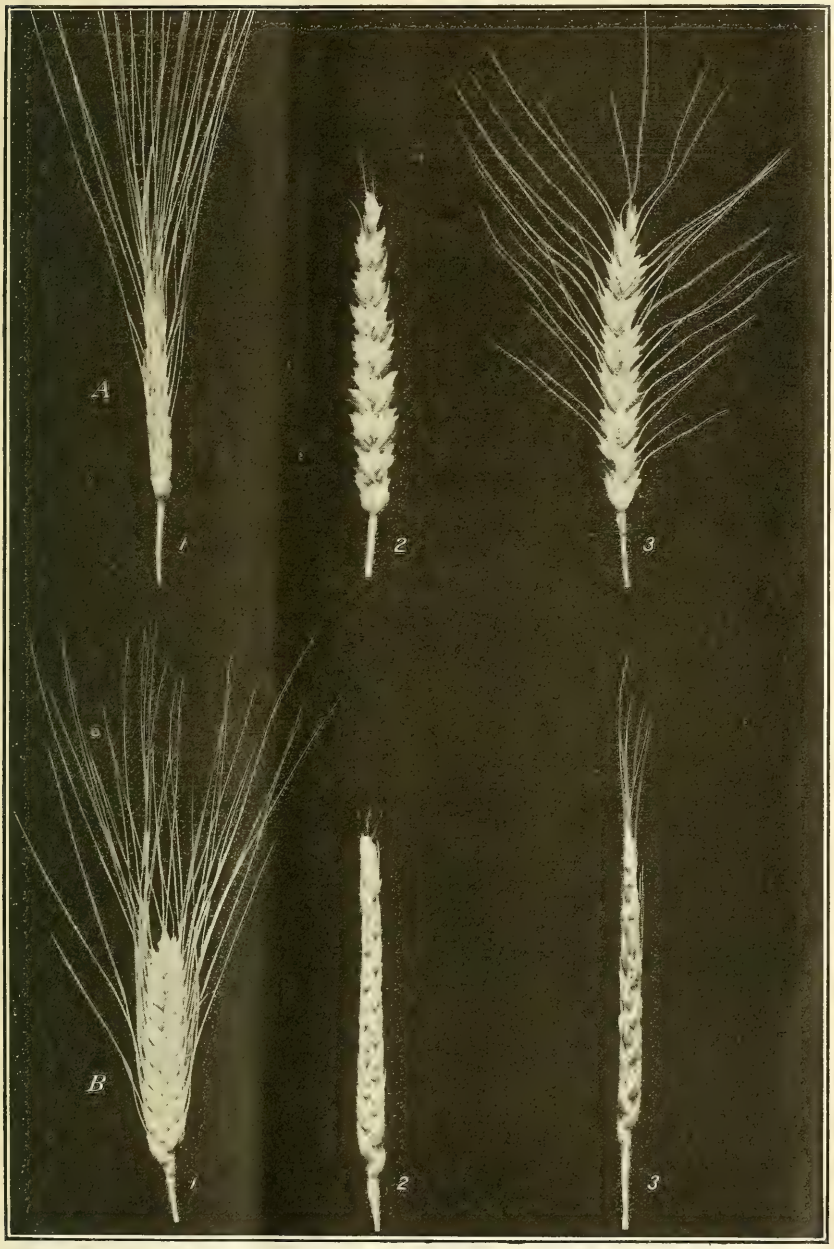

FIG. 5.—Heads of durum and common wheat in two positions: *A*, Face view of spikelets; *B*, edge view of spikelets. 1, Kubanka (durum); 2, Bluestem; 3, Preston.

somewhat translucent or vitreous. Some varieties of durum wheat have red kernels. Only one of these, D5,[1] has become commercially grown in the United States, and this at so recent a date that it is not discussed elsewhere in this bulletin.

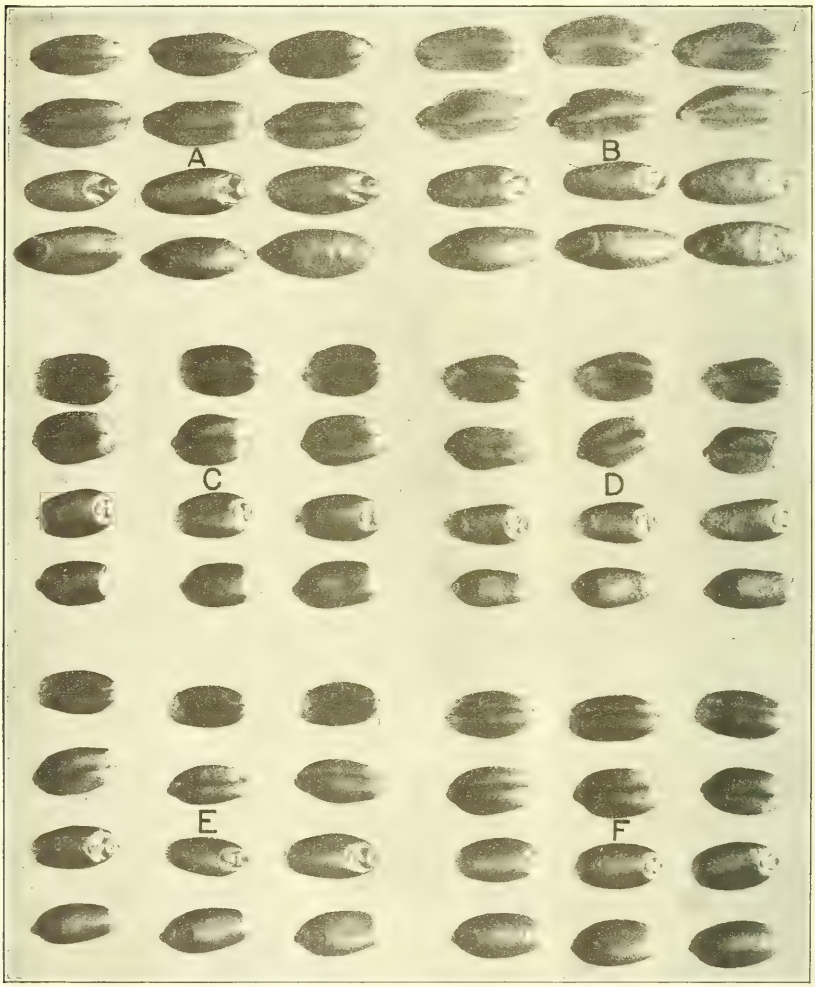

FIG. 6.—Kernels of two varieties of durum wheat and four varieties of common wheat, each variety representing a different group: *A*, Kubanka; *B*, Pelissier; *C*, Marquis (Fife); *D*, Haynes (Bluestem); *E*, Preston; *F*, Turkey (Crimean).

KEY TO GROUPS AND VARIETIES.

Below is given a key to the groups and varieties of durum wheat discussed in this bulletin. Heads of varieties representing the four chief groups are shown in figure 7.

[1] This variety originated from a selection made by Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station, in a field of durum wheat in Russia. It was tested, increased, and distributed by him as D5. It is an exceptionally rust-resistant variety, but of poor bread-making quality. This is the red durum on which is based the subclass "Red Durum" of the United States Grain Standards Act. (Houston, 1917.)

Key to the groups and varieties of durum wheat.

	Group.
Spike awned, flattened transversely to the plane of the rachis; kernel white (amber), vitreous (hard).	
Glumes glabrous.	
Glumes white to light brown.	
Awns white to light brown	*Kubanka.*
Spike oblong to broadly oblong.	
Beaks 1–2 mm. long.	
Plant tall. (Argentine, Beloturka, Buford, Gharnovka, Kubanka, Pererodka, Taganrog, Yellow Gharnovka.)	
Plant midtall; spike narrower. (Monad.)	
Beaks 1–10 mm. long. (Marouani, Saragolla.[1])	
Spike narrowly oblong, strongly nodding, beaks 1–3–ɔ mm. long. (Arnautka.)	
Awns black	*Pelissier.*
Beaks 1–2 mm. long. (Medeah.)	
Beaks 1–10 mm. long. (Pelissier.)	
Glumes thinly to densely pubescent.	
Glumes white. (Velvet Don.)	*Velvet Don.*
Glumes brown to black, beak 1–2 mm. long. (Black Don, Kahla, Purple.)	*Kahla.*

VARIETAL EXPERIMENTS.

This bulletin is believed to contain the results of all the important varietal experiments with durum wheats which have been conducted in the United States. The results of two experiments in Canada are included also. As early as 1892 the North Dakota Agricultural Experiment Station had a durum variety (Wild Goose) in its varietal experiments, and in 1893 it was included by the South Dakota Agricultural Experiment Station also. Experiments with durum wheat were begun in 1895 by the Canadian Department of Agriculture. From 1899 to 1903 stations in a number of different States began experiments with a series of durum wheat varieties.

The seed of the varieties tested by the Canadian stations was obtained by them. The varieties under experiment by the various stations in the United States were mostly those introduced by the United States Department of Agriculture from Russia and elsewhere, and the accession numbers they bear in the tabulated data are those of the Office of Cereal Investigations.

Geographic Scope.

Seventeen different States and Provinces are covered by the varietal experiments presented in this bulletin. They extend from Iowa and Wisconsin on the east to California and Oregon on the west, and from Texas on the south to Manitoba and Saskatchewan on the north. All

[1] A black-awned strain also is grown.

the intervening States are included except Oklahoma, New Mexico, Arizona, and Washington.

The adaptation and value of durum wheat vary with the environment. There is naturally a wide variation in soil and climate within this great expanse of territory. The eastern portion is distinctly humid, and the soil consists of glacial drift and alluvium. Farther west, in the Great Plains area, the precipitation decreases, the altitude increases, and the growing season becomes shorter. The soils are mostly heavy clay loams, varying to heavy clays or gumbo on the one hand and to sandy loams and sands on the other.

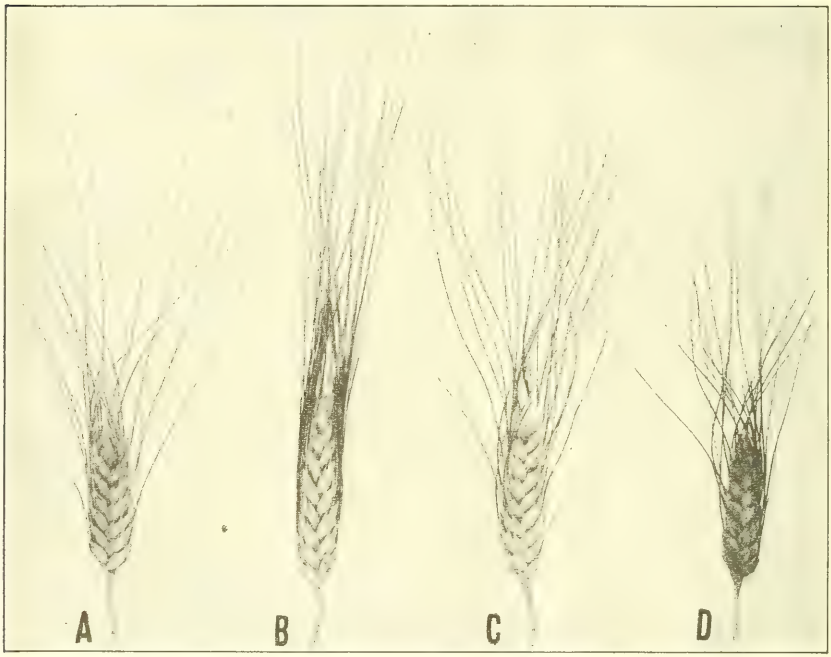

FIG. 7.—Heads of four different groups of durum wheat. *A*, Kubanka; *B*, Pelissier; *C*, Velvet Don; *D*, Kahla. (About half natural size.)

West of the Rocky Mountains new sets of conditions present themselves. The precipitation usually is low, and sometimes very low. The altitude in the great interior basins is high, except in the Columbia Basin, where it seldom exceeds 2,000 feet. In the California valleys the altitude is low. The soils throughout are mostly light in texture.

For convenience in presenting and interpreting results the territory under discussion is separated into three different divisions, according to the environmental conditions. These three divisions are called (1) the Prairie States, or subhumid area; (2) the Great Plains, or semiarid area; (3) the basin and coast or arid area, including the Salt Lake Basin, Snake River Basin, Humboldt Basin, Harney Valley, Columbia Basin, and the California valleys.

The locations of the stations, together with their altitude above sea level, are shown in Table II. The normal or average rainfall, in inches, with the number of years on which such average is based, also is given. The United States Weather Bureau establishes normals for their independent stations on 33-year records. At all other points the rainfall recorded is the average for the years during which observations have been made. Finally, the table shows the general soil type on which each station is located.

TABLE II.—*Altitude, normal and average precipitation, and soil type at 30 experiment stations at which experiments with durum wheat have been conducted.*

Area and station.	Altitude.	Precipitation.		Type of soil.
		Normal or average.	Length of record.	
	Feet.	*Inches.*	*Years.*	
Prairie (subhumid) area:				
McPherson, Kans.	1,495	31.22	26	Deep sandy loam.
Manhattan, Kans.	1,014	32.59	56	Dark-brown silt loam.
Lincoln, Nebr.	1,189	27.51	33	Alluvial clay loam.
Ames, Iowa.	922	32.64	40	Black silt loam.
Brookings, S. Dak.	1,636	20.51	27	Glacial sandy loam.
Ashland, Wis.	615	28.43	16	Red clay.
St. Paul, Minn.	837	28.68	33	Light clay loam.
Crookston, Minn.	863	21.76	26	Heavy clay loam.
Fargo, N. Dak.[a]	935	24.92	33	Heavy black clay loam.
Great Plains (semiarid) area:				
Amarillo, Tex.	3,676	21.21	24	Chocolate clay loam.
Hays, Kans.	2,000	23.16	48	Silty clay loam.
Akron, Colo.	4,560	19.72	11	Sandy loam.
North Platte, Nebr.	3,000	18.86	33	Loess.
Archer, Wyo.[b]	6,027	14.23	33	Medium sandy loam with some gravel.
Highmore, S. Dak.	1,890	16.75	22	Glacial clay loam.
Eureka, S. Dak.	1,884	16.43	7	Glacial sandy loam, stony portion of old moraine.
Newell, S. Dak.	2,900	14.06	8	Clay (gumbo), shale subsoil.
Edgeley, N. Dak.	1,468	18.05	15	Light sandy loam, shale subsoil.
Langdon, N. Dak.	1,615	17.88	4	Black clay loam.
Dickinson, N. Dak.	2,453	15.70	24	Sandy loam to clay loam.
Williston, N. Dak.	1,875	14.90	33	Fine sandy loam.
Moccasin, Mont.	4,228	16.66	18	Dark clay loam, gravelly subsoil.
Brandon, Manitoba	1,176	12.95	9	Sandy loam.
Indian Head, Saskatchewan	1,924	19.44	10	Light sandy to heavy loam, with clay subsoil.
Western basin and coast (arid) area:				
Nephi, Utah	6,000	13.48	17	Sandy clay loam.
Aberdeen, Idaho	4,400	9.46	4	Lava ash (sandy clay loam).
Burns, Oreg.	4,100	11.74	12	Silt loam to a very fine sandy loam.
Moro, Oreg.	1,800	11.35	11	Silt loam.
Chico, Cal.	189	23.59	45	Sandy loam.
Modesto, Cal.	90	10.52	44	Do.

[a] Observations made at Moorhead, Minn. [b] Observations made at Cheyenne, Wyo.

The stations listed in Table II are grouped in the three geographic divisions named. It will be noted that there is no sharp line of demarcation between the different divisions, either in rainfall, elevation, or soil type. For example, Amarillo, Tex., and Hays, Kans., located in the semiarid area, have a higher annual rainfall than Brookings, S. Dak., which is considered in the subhumid area. Not only is the rainfall at Amarillo higher than that of Brookings, but it is also higher than that of Crookston, Minn., and is slightly below that of

Fargo, N. Dak. The evaporation, however, is much higher at Amarillo than at these stations in the northern part of the subhumid division of the Great Plains area.

Results Obtained.

The results of varietal experiments with durum wheat at 30 different experiment stations are presented herein. At most of these stations the experiments have been conducted by the Office of Cereal Investigations, either cooperatively with the State experiment station or some other agency or independently. At the remaining stations the data have been obtained independently by the State or Province. The source of the data is stated in connection with each station.

The experimental conditions, such as crop sequence, size of plat, width of alleys, number of replications, etc., vary somewhat at different stations. The results obtained at one station, therefore, are not necessarily comparable with those obtained at any other station. In most cases, however, they probably are directly comparable. The results from different varieties at the same station were nearly always obtained under similar conditions and may be compared directly. Any known exceptions to this fact are stated in the text. In all cases the crops are grown with only the natural rainfall and under conditions approximating good farm practice for the district.

The value to crops of any given rainfall depends on the time and nature of its occurrence, on the kind of soil, and on the quantity and nature of the wind, as well as on other factors. Not one factor, but the total influence of all factors, must govern the classification of land for agricultural purposes.

The results from the durum varieties under experiment are shown for each station. Usually all varieties that have been grown for more than one or two years are included. In the tables they are separated into the major groups given in the key to groups and varieties.

The yields of the durum wheats are compared with those of the standard common wheats at each station. The highest yielding variety in each important group of common wheat is chosen for this comparison. Occasionally two varieties are given in one group, as in the Fife group, where such old standard varieties as Power, Glyndon, and Rysting are now being outyielded by Marquis.

In figures 8, 12, and 13, the vertical column showing the yield of durum wheat is based on the yield of only the highest yielding variety in the period of years indicated, except when otherwise noted.

RESULTS IN THE SUBHUMID PRAIRIE SECTION.

The prairie section (fig. 8) includes the stations in Wisconsin, Minnesota, Iowa, eastern Kansas and Nebraska, and extreme eastern North and South Dakota. Nine stations which have experimented with durum wheat are located in this section. The names of these

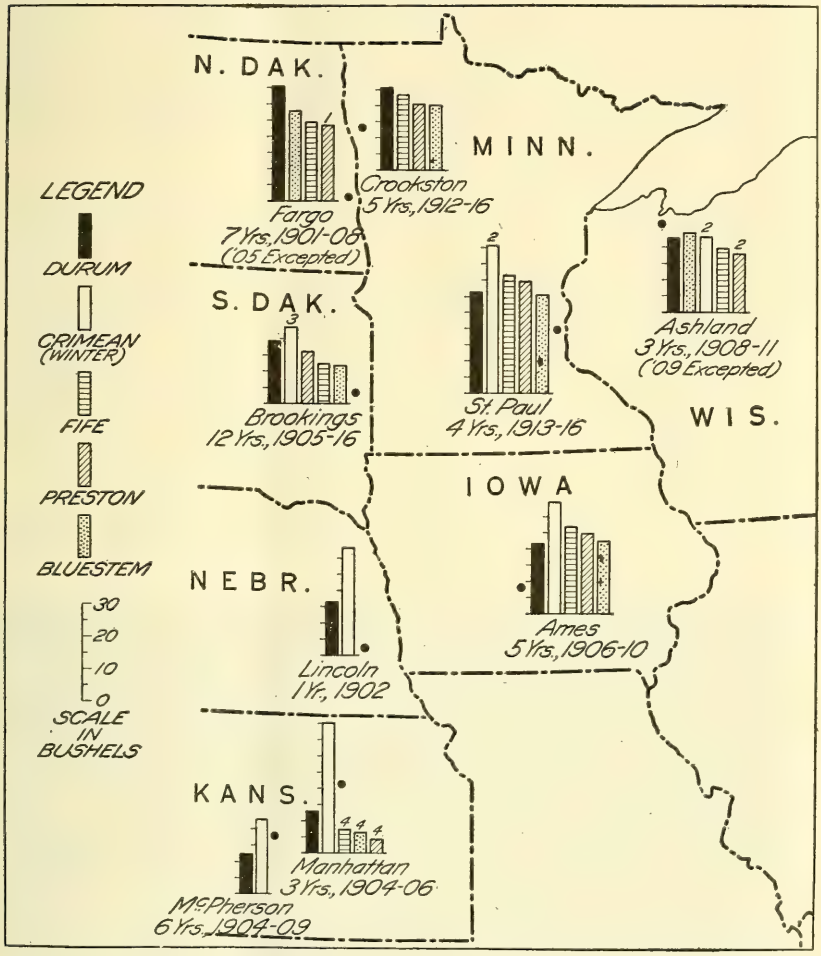

FIG. 8.—Diagram showing the location of nine stations in the Prairie States and the average yield of the leading variety of durum and the leading variety of each of several different groups of common wheat at each station during the periods of years indicated: 1, Average of only four years (Preston at Fargo); 2, average of only three years (Crimean at St. Paul and Crimean and Preston at Ashland); 3, average of only ten years (Crimean at Brookings); 4, average of only two years (Fife, Bluestem, and Preston at Manhattan).

stations, their altitude, normal or average annual rainfall for a period of years, and the general soil type on which they are located have already been given in Table II.

Experiments with durum wheat have been conducted at some other stations adjacent to the subhumid section on the east and

also at stations in some of the Eastern and Southern States. These tests have all been of short duration. The principal ones were conducted at Madison, Wis.; DeKalb, Ill.; Arlington Farm, at Rosslyn, Va.; Statesville, N. C.; and Athens, Ashburn, and Quitman, Ga. At Madison, Wis., and De Kalb, Ill., durum varieties were found not adapted and were discarded because of poor quality of grain or low yields. At the stations in the Eastern and Southern States the durum varieties were grown with the winter wheats adapted to those sections. Fair yields were obtained from durum varieties when fall sown, but all were low in comparison with the yields of the common wheats.

In general, the altitude in the Prairie States increases and the precipitation decreases from east to west. The altitude varies from 600 to 1,600 feet, in round numbers. The average annual rainfall at these stations varies from 32.6 to 20.5 inches. The three stations having the lowest rainfall are located in the valleys of the Sioux and Red Rivers near the Minnesota-Dakota boundary. Properly speaking, these valleys are the only portions of this section that can be called subhumid. Most of the remainder would be better designated as humid, although the eastern portions of Nebraska and Kansas might easily be placed as either subhumid or humid territory.

The annual rainfall usually is sufficient for normal crop production. Nearly half of it falls during the four summer months, from May to August, inclusive. The growing season is fairly long, varying from about 130 to more than 150 days.

Figure 8 shows, by means of graduated columns, the average yield of the best durum-wheat variety and of the leading variety in each of several groups of common wheat in varying periods of years at the nine stations. The same data will be found in tabulated form in Tables III to XI, inclusive.

Figure 9 shows heads of five varieties of wheat, one durum and four common, each representative of a group important in the prairie section and in the Great Plains area.

RESULTS AT M'PHERSON, KANS.

As shown in Table II (page 15), McPherson is located on a deep sandy loam at an altitude of almost 1,500 feet. The average precipitation has been 31.2 inches in a 26-year period. The experiments at McPherson were conducted in cooperation with the Kansas Agricultural Experiment Station. The results are shown in Table III and graphically in figure 8.

Durum varieties were under experiment for six years, though in one year, 1908, the records of the yields of all varieties but one were lost. Since McPherson is located outside of the spring-wheat belt, no spring varieties of common wheat were grown. Hard red winter wheats of the Crimean group, such as Crimean, Kharkof, and Turkey,

are the standard varieties in that district. The durum varieties are compared, therefore, with Kharkof (C. I. No. 1442), one of the best yielders in the Crimean group.

TABLE III.—*Annual and average yields of five varieties of durum wheat and one variety of common wheat grown at the McPherson (Kans.) substation during periods of varying length in the six years from 1904 to 1909, inclusive.*

[Data obtained in cooperation with the Kansas Agricultural Experiment Station.]

Class, group, and variety	C. I. No.[a]	Yield per acre (bushels).							
		1904	1905	1906	1907	1908	1909	Average.	
								5 years, 1904–1907 and 1909.	6 years, 1904 to 1909.
Durum:									
Kubanka—									
Kubanka	2246	16.3	14.2	24.0	0	(b)	13.8	13.7	.....
Do	2094	12.7	11.3	25.6	0	13.5	12.6	12.4	12.6
Kahla—Black Don	2100	11.7	14.5	24.5	0	(b)	13.4	12.8	.....
Pelissier—									
Pelissier	2086	11.0	11.7	21.7	0	(b)	11.6	11.2	.....
Saragolla	2228	10.3	9.8	16.7	0	(b)	10.9	9.5	.....
Common:									
Crimean (winter)—Kharkof	1442	25.9	18.4	35.1	20.9	19.5	19.5	24.0	23.2

[a] Cereal Investigations number. [b] Record of yields lost.

Reference to Table III and figure 8 shows that the Kharkof winter wheat outyields the best durum variety in the ratio of nearly 2 to 1. Among the durum varieties a Kubanka leads. Since this district is

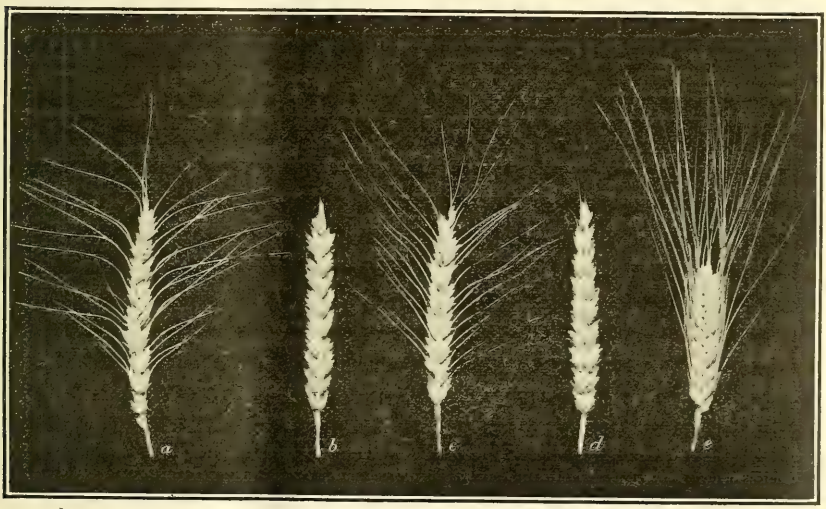

FIG. 9.—Heads of representative varieties of five groups of wheat: *a*, Turkey, a hard red winter wheat; *b*, Fife; *c*, Preston; *d*, Bluestem; *e*, Kubanka (durum; edge view).

not suited to the growing of spring-sown varieties of wheat, it is not surprising that the Crimean wheat so far surpasses the durum. In 1906, however, the yields of the durum varieties ranged from 16.7

to 25.6 bushels, while the 5-year average yields of four varieties ranged from 11.2 to 13.7 bushels. This shows that in the event of great damage to the winter-wheat crop in autumn or winter the loss might be retrieved in a large measure by sowing durum wheat the following spring.

RESULTS AT MANHATTAN, KANS.

Manhattan is located, according to Table II (p. 15), on a dark-brown silt-loam soil at an altitude of 1,014 feet. The normal annual rainfall, based on a 56-year record, is 32.6 inches. The experiments were conducted independently by the Kansas Agricultural Experiment Station, and the results are copied from Bulletin 144 (Ten Eyck and Shoesmith, 1907) of that station. The results are shown in full in Table IV and graphically in figure 8.

TABLE IV.—*Annual and average yields of two varieties of durum wheat and four varieties of common wheat grown at the Kansas Agricultural Experiment Station, Manhattan, Kans., during periods of varying length in the four years from 1903 to 1906, inclusive.*

Class, group, and variety.	Yield per acre (bushels).					
					Average.	
	1903	1904	1905	1906	2 years, 1903 and 1904.	3 years, 1904 to 1906.
Durum:						
Kubanka—Gharnovka	13.3	11.1	.....	.....	12.2	.....
Velvet Don—Velvet Don	12.0	7.0	18.0	12.8	9.5	12.6
Common:						
Crimean—Turkey (No. 4)	.....	34.9	38.6	46.9	.....	40.1
Fife—Glyndon	9.6	5.3	.....	.....	7.5	.....
Bluestem—Haynes	7.0	6.1	.....	.....	6.6	.....
Preston—Preston	7.0	1.9	.....	.....	4.5	.....

Since Manhattan, like McPherson, lies in the heart of the Crimean winter-wheat belt, the experiments are of brief duration, as not much could reasonably be expected of spring-wheat varieties. Table IV shows the comparative yields in the years 1903 and 1904 of two durum varieties and of three spring common wheats belonging to three different groups. It is seen that both durums exceed any of the spring common varieties in yield. The Turkey variety of the Crimean winter group, however, outyields the best durum grown in a ratio of 3 to 1. In the favorable year 1905, in which one of the durum varieties was still under experiment, its high yield of 18 bushels was less than half that of Turkey, 38.6 bushels per acre.

RESULTS AT LINCOLN, NEBR.

The Nebraska Agricultural Experiment Station is located on an alluvial clay-loam soil at an altitude of 1,189 feet above sea level. The normal precipitation is 27.5 inches. The experiments at Lincoln were conducted independently by the Nebraska Agricultural Experi-

ment Station, and the data given in Table V are taken from publications of that station (Lyon, 1903; Lyon and Keyser, 1905). The principal data are shown also graphically in figure 8.

TABLE V.—*Yields of seven varieties of durum wheat and three varieties of common wheat grown at the Nebraska Agricultural Experiment Station, Lincoln, Nebr., in 1902.*

Class, group, and variety.	Yield per acre (bushels).	Class, group, and variety.	Yield per acre (bushels).
Durum:		Durum—Continued.	
Kubanka—		Kahla—Kahla	7.3
Gharnovka	16.5		
Yellow Gharnovka	14.5	Common:	
Pererodka	14.0	Crimean (winter)—	
Kubanka	12.5	Turkey	33.2
Velvet Don—Velvet Don	10.5	Crimean	29.2
Pelissier—Pelissier	7.5	Kharkof	22.3

As shown in Table V, the durum wheats were tested at Lincoln in but a single year, 1902. Lincoln lies in the heart of the hard winter-wheat belt, and spring-sown wheat can not compete with the varieties of the Crimean group. The average yield of the seven durum varieties is only 11.8 bushels, whereas the average yield of the three Crimean varieties is 26.2 bushels per acre. The yield of the best durum, Gharnovka, in the Kubanka group, is 16.5 bushels, whereas the yield of the best Crimean, Turkey, is 33.2 bushels per acre, or exactly double the yield of the Gharnovka. On the basis of known facts, there was no economic reason for continuing further a varietal experiment with durum wheat at Lincoln.

RESULTS AT AMES, IOWA.

Ames, Iowa, as seen from Table II, is located on the Marshall silt-loam soil at an altitude of 922 feet. The average annual rainfall for a 40-year period is 32.6 inches. The experiments cited were conducted cooperatively by the Iowa Agricultural Experiment Station and the Office of Cereal Investigations.

Experiments including durum wheat cover the 5-year period from 1906 to 1910, inclusive. The results are given in Table VI, and the principal ones are shown graphically in figure 8.

Among the durums only Kubanka was tried, and the results are unfavorable when compared with those from the other varieties. None of the spring wheats does well, but all three of the spring common varieties are better than Kubanka. As might be expected in central Iowa, winter wheat is much more productive than any spring wheat. The 5-year average yield of Turkey, of the Crimean group, is nearly 10 bushels higher than that of the best spring common wheat. Durum wheats have no place in so humid a climate as that of central Iowa.

TABLE VI.—*Annual and average yields of one variety of durum wheat and four varieties of common wheat grown at the Iowa Agricultural Experiment Station, Ames, Iowa, during periods of varying length in the five years from 1906 to 1910, inclusive.*

[Data obtained in cooperation with the Iowa Agricultural Experiment Station.]

Class, group, and variety.	Yield per acre (bushels).						
						Average.	
	1906	1907	1908	1909	1910	3 years, 1908 to 1910.	5 years, 1906 to 1910.
Durum:							
Kubanka—Kubanka	21.4	22.5	14.3	14.5	34.5	21.1	21.5
Common:							
Crimean (winter)—Turkey	39.7	37.4	37.6	27.7	30.0	31.8	34.5
Preston—Early Java	25.1	20.5	15.7	26.5	36.7	26.3	24.9
Fife—Glyndon (Minn. No. 163)	.....	.....	17.2	21.3	41.6	26.7	.....
Bluestem—Haynes (Minn. No. 169)	24.1	19.6	8.7	23.0	38.3	23.3	22.7

RESULTS AT BROOKINGS, S. DAK.

According to Table II (p. 15), Brookings is situated on a glacial sandy loam at an altitude of 1,636 feet, the greatest elevation of any station in the prairie section. The average rainfall, based on a 27-year period, is 20.5 inches. The experiments were conducted cooperatively by the South Dakota Agricultural Experiment Station and the Office of Cereal Investigations.

The experiments were begun in 1904 and have continued until the present time. Results during periods of varying length in the 13 years from 1904 to 1916, inclusive, are shown in Table VII and graphically in figure 8.

Brookings lies in the hard spring-wheat belt, and the durum wheats should be adapted to the conditions of that locality, though the rainfall is a little too high for the development of the highest quality. The annual and average yields of five varieties, two durums and three representative common wheats, are recorded for a 12-year period. The two durums, Arnautka and Kubanka, both in the Kubanka group, excel all three common wheats. One of the durums, Arnautka, outyields the common varieties by a significant average yield of 3.5 bushels per acre. Among the common wheats, Preston outyields Fife and Bluestem by 3.5 and 4.1 bushels, respectively. The Marquis variety was grown only during the last four years of the experiment. In those years, however, it outyielded all other varieties of common and durum wheat. The yields of winter wheat of the Crimean group have not been obtained consecutively throughout this period. In the 10 years, however, in which it was grown it has exceeded the Arnautka in yield by an average of 1.8 bushels.

Eight varieties of durum wheat, all in the Kubanka group, have been tested for periods of 5, 9, or 12 years. The Arnautka variety has proved best adapted, outyielding the Kubanka in each of the

three periods of years mentioned. During the last five years of the test, however, the Kubanka has the advantage.

The results show that durum wheats of the Kubanka group are profitable varieties for the Big Sioux Valley. They have outyielded all spring common wheats except Marquis.

TABLE VII.—*Annual and average yields of eight varieties of durum wheat and five varieties of common wheat grown at the South Dakota Agricultural Experiment Station, Brookings, S. Dak., during periods of varying length in the thirteen years from 1904 to 1916, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).													Average.		
		1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	5 years, 1904 to 1908.	9 years, 1904 to 1912.	12 years, 1905 to 1916.
Durum:																	
Kubanka—																	
Arnautka	1494	26.0	25.0	35.8	20.8	25.8	16.5	12.0	4.0	26.1	25.8	11.2	22.5	[a]11.1	26.7	21.3	19.7
Do.	1493	23.5	25.0	36.4	17.5	23.1	17.3	11.0	0	31.0	....	....	....	....	25.1	20.5	.....
Kubanka	1440	18.8	16.3	28.6	14.5	16.1	11.8	12.7	1.2	28.0	28.3	15.0	17.0	11.6	18.9	16.4	16.8
Do.	1541	18.6	16.5	30.4	12.7	15.8	18.0	9.2	3.8	21.6	....	....	....	....	18.8	16.3	.....
Do.	1516	19.3	20.8	30.3	6.2	12.8	15.7	5.5	2.8	28.6	....	....	....	....	17.9	15.8	.....
Do.	1354	21.0	18.8	38.5	15.6	16.0	....	....	....	....	....	....	....	....	22.0	.....	.....
Gharnovka	1546	16.1	22.2	32.5	13.8	20.1	....	....	....	....	....	....	....	....	20.9	.....	.....
Kubanka	1490	22.5	18 5	28 4	11.1	12.6	....	....	....	....	....	....	....	....	18.6	.....	.....
Common:																	
Preston—Preston	3081	....	18.3	22.3	10.9	15.0	21.8	19.0	2.8	18.5	27.6	12.7	18.3	7.5	.....	.....	16.2
Fife—																	
Marquis	3641	....	....	....	....	....	....	....	....	....	29.3	15.8	26.7	7.2	.....	.....	.....
Rysting	3022	....	15.8	23.4	7.3	14.9	15.5	16.9	3.0	16.8	20.0	[b]9.2	[b]7.5	[b]2.6	.....	.....	12.7
Bluestem—																	
Haynes	2874	....	16.3	21 8	8.4	11.6	16.9	15.7	2.8	[c]15.8	[c]20.2	2.5	12.5	.6	.....	.....	12.1
Crimean (winter)—Turkey	3055	21.0	22.0	8.0	9.4	(d)	14.4	(d)	(d)	29.3	34.2	30.8	43.3	26.1	.....	.....	.....

[a] Not grown; yield of Arnautka (C. I. No. 4064), a pure line selection from C. I. No. 1494, substituted.
[b] Not grown; yield of Glyndon (C. I. No. 2873) substituted.
[c] Not grown; yield of Haynes (Minn. No. 185) substituted.
[d] Winter wheats not grown.

RESULTS AT ASHLAND, WIS.

Ashland, as seen in Table II (p. 15), lies on the Superior red clay at the low altitude of 615 feet above sea level. The average annual rainfall is 28.4 inches in a 16-year period. The experiments presented in Table VIII and shown graphically in figure 8 were conducted by the Wisconsin Agricultural Experiment Station. The data have been taken from Bulletin 233 of that station (Delwiche and Leith, 1913).

The experiments continued during the four years from 1908 to 1911, inclusive. The yields of one durum, Kubanka, and three common varieties, representing three leading groups of hard spring common wheat, are presented. One winter wheat, Kharkof, of the Crimean group, also was grown. Since Ashland is near the northern edge of the winter-wheat belt, it is not surprising that the Kharkof does not excel all the spring varieties.

Kubanka durum excels Preston and Fife by yields that are fairly significant. It nearly ties with Kharkof for second place, but is outyielded by Bluestem to a degree that is fairly significant. Whether it would pay to grow a durum variety under these conditions would depend in part upon the average quality of the grain of the different varieties and in part on the frequency of rust attack.

TABLE VIII.—*Annual and average yields of one variety of durum wheat and four varieties of common wheat grown at the Ashland (Wis.) branch station during periods of varying length in the four years from 1908 to 1911, inclusive.*

Class, group, and variety.	Yield per acre (bushels).					
					Average.	
	1908	1909	1910	1911	3 years, 1908, 1910, and 1911.	4 years, 1908 to 1911.
Durum:						
Kubanka—Kubanka	22.1	22.0	26.0	22.1	23.4	23.0
Common:						
Bluestem—Haynes (Minn. No. 169)	27.7	18.2	27.3	26.4	27.1	24.9
Crimean (winter)—Kharkof	15.0	(a)	22.8	33.0	23.6	.....
Fife—Glyndon (Minn. No. 163)	18.7	16.8	26.0	18.8	21.2	20.0
Preston—"Selected Bearded"	17.0	.....	20.7	17.0	18.2	.....

a Excessive rainfall (more than 12 inches in 3 days) in July, 1909, so affected the yields of winter wheat that they were not considered of value for comparative purposes.

RESULTS AT ST. PAUL, MINN.

The Agricultural Experiment Station at University Farm, St. Paul, Minn., is situated in a light sandy loam soil at an altitude of 837 feet. The normal annual rainfall is 28.7 inches. The experiments have been conducted independently by the Minnesota Agricultural Experiment Station, and the results are presented here by the courtesy of the director and his associates.

The yields presented include those of five varieties of wheat, namely, Kubanka durum and a leading representative each of the Crimean group of hard red winter wheats and the Fife, Preston, and Bluestem groups of hard spring wheat. The data are given in Table IX and are shown graphically in figure 8.

It will be noted that in the 3-year period, 1914 to 1916, inclusive, the Turkey winter wheat outyields all the others by 11 to 15 bushels per acre. Marquis, in the Fife group, outyields all the other spring wheats by about 1 bushel per acre, Kubanka durum standing second. In 1913 the Turkey wheat was not grown, while the yield of Kubanka was comparatively low. In the four years from 1913 to 1916, inclusive, the Kubanka is outyielded by Marquis, Glyndon, and Preston in quantities that are significant, while it outyields Haynes by only 0.7 bushel.

From the showing made in these years the growing of durum wheats in the vicinity of St. Paul would be justified only by their superior rust resistance in comparison with common wheats.

TABLE IX.—*Annual and average yields of one variety of durum wheat and five varieties of common wheat grown at the Minnesota Agricultural Experiment Station, University Farm, St. Paul, Minn., during periods of varying length in the four years from 1913 to 1916, inclusive.*

[Data presented by courtesy of the Minnesota Agricultural Experiment Station.]

Class, group, and variety.	Minn. No.	Yield per acre (bushels).					
		1913	1914	1915	1916	Average.	
						3 years, 1914 to 1916.	4 years, 1913 to 1916.
Durum:							
Kubanka—Kubanka	990	25.7	30.3	46.7	23.8	33.6	31.6
Common:							
Crimean (winter)—Turkey	845	.....	47.8	57.0	33.3	46.0	.....
Fife:							
Marquis	1239	41.9	27.7	50.0	26.3	34.7	36.5
Glyndon	285	38.6	27.0	49.2	23.2	33.1	34.5
Preston—Preston	924	43.5	26.5	46.7	22.7	32.0	34.9
Bluestem—Haynes	169	33.8	26.7	39.9	23.3	30.0	30.9

RESULTS AT CROOKSTON, MINN.

The Northwest Experiment Station at Crookston, Minn., is located on a heavy clay loam at an altitude of 863 feet. It has an average annual rainfall of 21.8 inches in a 26-year period. The experiments there have been conducted independently by the Minnesota Agricultural Experiment Station and are presented here through the courtesy of the director and his associates.

The data cover the period of five years from 1912 to 1916, inclusive, as shown in Table X and figure 8. Yields are given of three durum wheats of two different groups and of four common wheats, representing the three leading spring groups. The three durum varieties excel Glyndon, Haynes, and Preston by from 2 to 5 bushels per acre. Only the two durums in the Kubanka group outyield Marquis, however, and then by only 0.6 bushel in one case and 1.9 bushels in the other.

TABLE X.—*Annual and average yields of three varieties of durum wheat and four varieties of common wheat grown at the Northwest Agricultural Experiment Station, Crookston, Minn., during the five years from 1912 to 1916, inclusive.*

[Data presented by courtesy of the Minnesota Agricultural Experiment Station.]

Class, group, and variety.	Yield per acre (bushels).					
	1912	1913	1914	1915	1916	5-year average.
Durum:						
Kubanka—						
Mindum (Minn. No. 951)	33.4	21.6	22.3	34.5	16.6	25.7
Kubanka	32.2	27.8	14.6	38.0	9.6	24.4
Velvet Don—Velvet Don	28.2	25.3	13.4	32.6	11.6	22.2
Common:						
Fife—						
Marquis[a]	27.8	21.4	23.9	40.0	5.8	23.8
Glyndon (Minn. No. 163)	26.5	20.4	17.8	30.9	3.1	19.7
Preston—Preston	33.4	18.2	17.7	28.1	4.9	20.5
Bluestem—Haynes (Minn. No. 169)	38.5	17.4	19.2	23.3	2.2	20.1

[a] Average of the yields of two plats.

On the average, the durum varieties are the better at Crookston. Winter wheat can not be grown successfully in this locality, and only the Marquis approaches closely the best durums in yield. Among the three durum varieties under test, the Kubanka and a pure-line selection (Minn. No. 951) closely resembling Arnautka are better adapted than the Velvet Don. The Arnautka selection, which has been named Mindum by the Minnesota Agricultural Experiment Station, outyielded Kubanka in the 5-year test by 1.3 bushels per acre. Here, as at Brookings, S. Dak., Arnautka has proved to be slightly better adapted than Kubanka. The close agreement in yield between the Glyndon, Haynes, and Preston varieties is remarkable, showing that here all three groups of hard spring common wheat are at home. Farther east only the Bluestem group does well, but farther west it is decidedly inferior to the other two.

RESULTS AT FARGO, N. DAK.

Fargo is located on a heavy black clay loam at an altitude of 935 feet above sea level. Its normal annual rainfall is 24.9 inches. These data, in comparison with those from all the other stations, will be found in Table II (p. 15). The experiments here were conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations. The results obtained are presented in Table XI. The principal data are shown graphically also in figure 8.

The experiments cover seven years, 1901 to 1904, inclusive, and 1906 to 1908, inclusive. Eleven varieties of durum wheat are included, of which 10 belong to the Kubanka group. It is striking that among the 7-year average yields of these 10 there is a range of only 2.9 bushels. This difference is scarcely significant when the lowest and highest yields are, respectively, 33 and 35.9 bushels per acre. The difference in yield between the now commonly grown varieties, Arnautka and Kubanka, is not significant, although the slight difference is in favor of Kubanka. Here again the durums all outyield the best representatives of the standard spring common wheats by quantities that usually are significant. Winter wheat can not be grown successfully in this locality.

The Bluestem slightly excels Fife, and that in turn outyields Preston. In 1904, the year of a severe rust epidemic, the durums yielded better than common wheats. In 1906, however, the Bluestem outyielded all durums except Arnautka. A summary of the results shows that durum wheat yielded better than common wheat in the Red River Valley in the 7-year period, a conclusion fully in accord with farm yields in that district. Since 1908 the experiments have been conducted independently by the North Dakota Agricultural Experiment Station, but the results are not yet available.

TABLE XI.—*Annual and average yields of twelve varieties of durum wheat and three varieties of common wheat grown at the North Dakota Agricultural Experiment Station, Fargo, N. Dak., during periods of varying length in the seven years from 1901 to 1904 and 1906 to 1908, inclusive.*[a]

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	N. Dak. No.	Yield per acre (bushels).								
										Average.	
			1901	1902	1903	1904	1906	1907	1908	4 years, 1901 to 1904.	7 years, 1901 to 1904 and 1906 to 1908.
Durum:											
Kubanka—											
Gharnovka	1447	917	32.4	30.3	46.5	23.6	24.0	47.8	47.0	33.2	35.9
Taganrog	1570	911	29.7	31.7	46.7	18.5	25.3	55.6	38.2	31.7	35.1
Pererodka	1350	328	34.7	25.7	47.0	17.8	24.3	54.6	39.2	31.3	34.8
Kubanka	1349	329	32.4	28.7	44.0	17.6	22.0	50.0	46.7	30.7	34.5
Yellow Gharnovka	1444	914	30.8	33.0	41.7	24.7	25.0	49.5	36.4	32.6	34.4
Kubanka	1440	929	32.4	28.7	44.0	21.9	24.3	50.0	38.5	31.8	34.3
Beloturka	1513	919	32.6	29.9	46.3	17.8	22.3	53.1	36.7	31.7	34.1
Arnautka	1494	778	34.0	28.7	43.4	20.5	27.3	49.6	33.2	31.7	33.8
Argentine	1569	910	28.4	29.5	44.6	24.0	23.5	52.5	29.2	31.6	33.1
Gharnovka	1443	915	31.4	25.8	44.5	20.8	24.6	48.0	36.0	30.6	33.0
Velvet Don—Velvet Don	1445	930	29.6	32.5	42.6	18.5	24.0	48.1	35.5	30.8	33.0
Common:											
Bluestem—Haynes	1505	779	29.7	21.2	39.3	15.2	26.3	[b]32.2	34.0	26.4	28.3
Fife—Power	1506	920	27.0	23.1	38.5	15.2	18.3	24.6	[c]26.2	26.0	24.7
Preston—Preston	2958	210	24.9	25.0	38.7	7.1	.....	.....	.....	23.9	.....

[a] The crop of 1905 could not be harvested, owing to rain.
[b] Yield of a selection (C. I. No. 3083, N. Dak. No. 316) from Haynes, C. I. No. 1505, substituted.
[c] Yield of a selection (C. I. No. 3697, N. Dak. No. 313) from Power, C. I. No. 1506, substituted.

RESULTS IN THE SEMIARID GREAT PLAINS AREA.

The Great Plains area includes parts of all the States and Provinces from Texas on the south to Manitoba, Saskatchewan, and Alberta on the north. Roughly speaking, it extends from the line of 30-inch rainfall westward to the Rocky Mountains. Under this definition it includes part of the territory just discussed as in the subhumid section. The separation made in this paper between semiarid and subhumid is not exactly the one commonly used and is made here only in order to permit a better interpretation of the behavior of durum wheat.

In altitude, this division rises from 1,000 or 1,500 feet on its eastern border to 2,000 or 3,000 feet through its central portion, and to maximum altitudes in the west of 6,000 feet in eastern Wyoming and of 6,500 feet in east-central Colorado. Figure 10 is a contour map of the Great Plains area in the United States on which the altitudes are indicated by lines drawn on the contours of 1,000, 1,500, 2,000, 3,000, 4,000, 5,000, and 6,000 feet. The drainage is to the southeast in the southern portion, to the east in the central portion, and to the northeast in the northern portion.

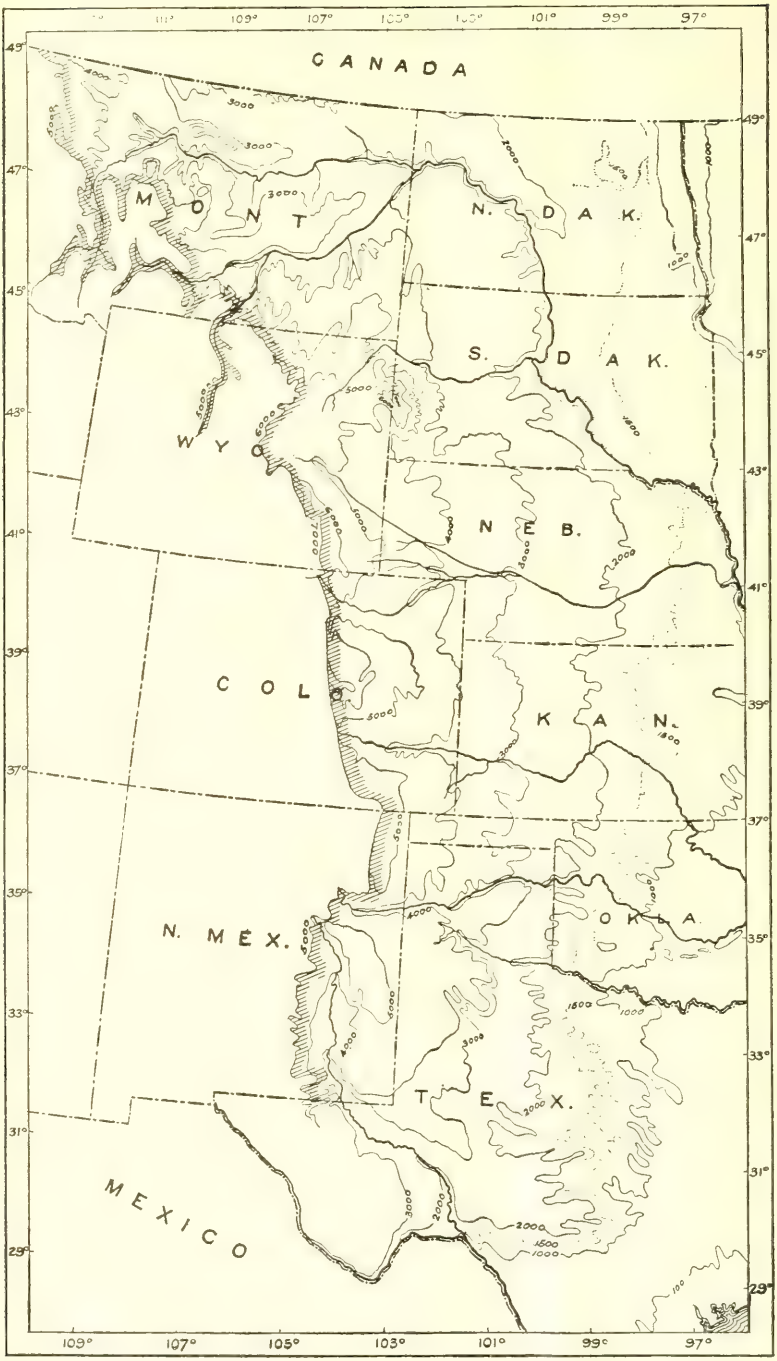

FIG. 10.—Map of the Great Plains area, showing the altitudes above sea level by means of lines following the contours at 1,000, 1,500, 2,000, 3,000, 4,000, 5,000, and 6,000 feet.

The climate is classed generally as semiarid. The average annual precipitation over most of this area varies from 14 to 20 inches. Only in the extreme southern part and along the eastern border is this quantity exceeded. In general, the annual rainfall decreases from east to west across the Great Plains with the increase in altitude. Figure 11 shows the distribution of precipitation in the Great Plains area of the United States by means of lines drawn through points having the same average precipitation.

Crop production is governed largely by the quantity and distribution of the annual rainfall. Half to two-thirds of it comes during the growing season, the four months from April to July, inclusive. Wind movement is fairly constant, and summer temperatures are rather high. These factors cause rapid loss of water by evaporation. Both hot winds and hail sometimes occur, though hot winds are not known at the higher altitudes. Wet weather in midsummer is conducive to rust infection, which frequently occurs locally and sometimes extends to a general epidemic throughout the area.

The length of the growing season varies with the altitude and latitude. The frost-free period decreases from about 130 days in the lower portions to about 90 days at the higher altitudes. In general, early varieties have an advantage in escaping hot winds, drought, and frost. A brief popular classification and description of the important groups of hard spring wheat and the leading varieties in each group is already available (Ball and Clark, 1915 *b*). Plants, spikes, and kernels of representative varieties of the chief groups of wheat grown in this area are shown in figures 4, 5, 6, 7, and 9.

Experiments conducted at 15 stations in the Great Plains area are discussed in the following pages. The name of each station, the altitude in feet above sea level, the normal or average rainfall, and the period of years on which it is based, together with the soil type on which each is located, are all shown in Table II (p. 15). Figure 12 is an outline map of this area, showing the location of each station and, by means of graduated columns, the average yield of the best variety of durum wheat and of the best variety of each group of common wheat during the years indicated. Thirteen of these stations are in the United States and two are in the Dominion of Canada. Durum wheat has been under test at the two Canadian stations since 1895. None of the experiments in the United States began earlier than 1902, as most of the stations were established later than that date. For the most part they are substations of the State agricultural experiment station or independent field stations of the United States Department of Agriculture.

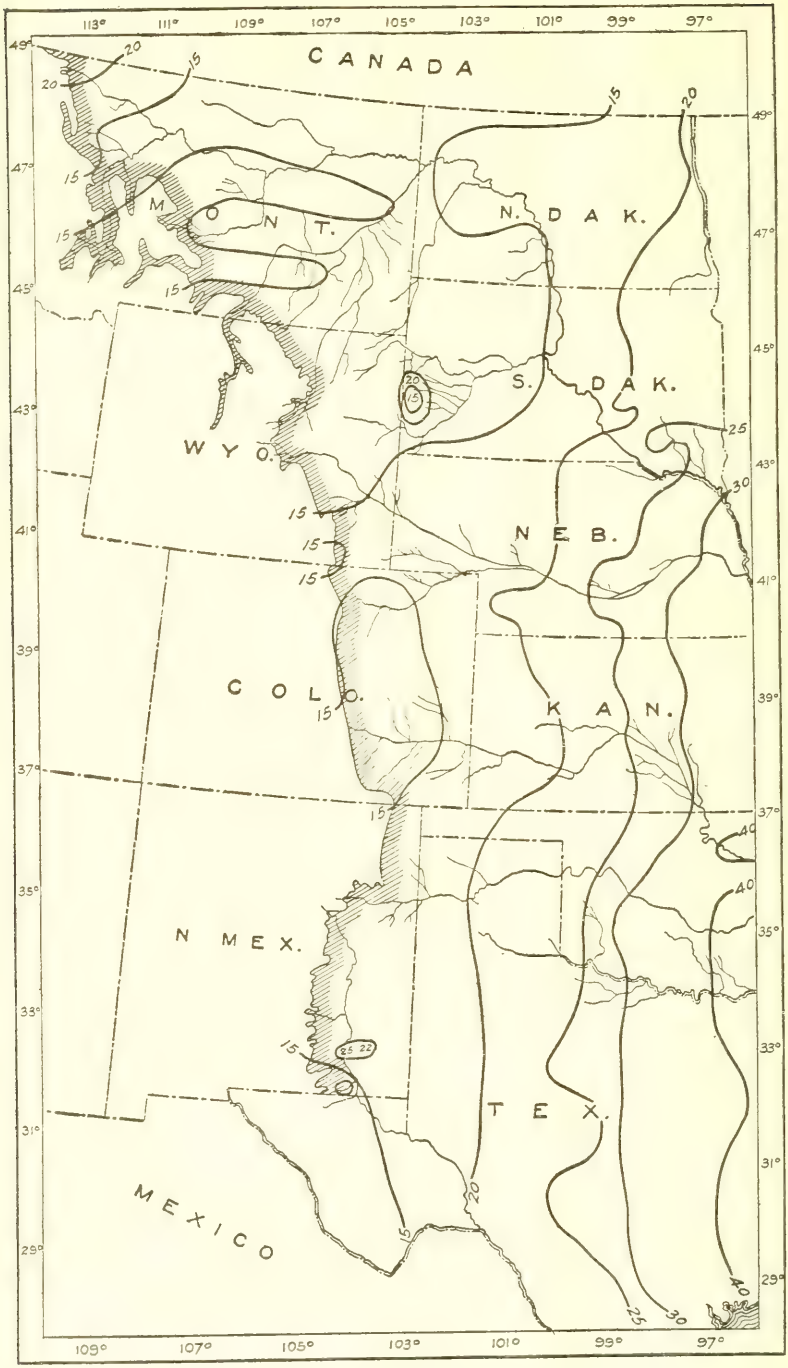

FIG. 11.—Map of the Great Plains area, showing the average yearly rainfall in inches by means of lines drawn through places having about the same rainfall.

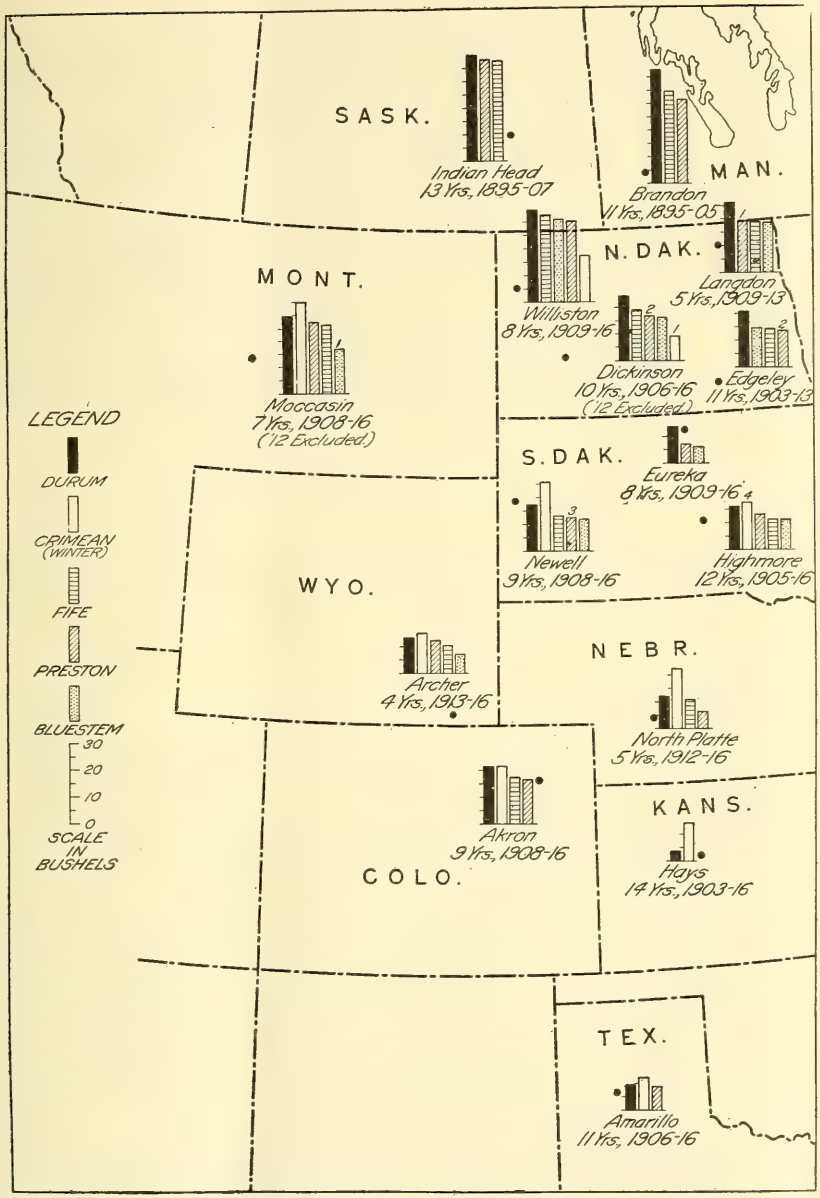

FIG. 12.—Diagram showing the location of fifteen stations in the Great Plains area and the average yield of the leading variety of durum wheat and the leading variety of each of several different groups of common wheat at each station during the periods of years indicated: 1, Average of only four years (Bluestem at Moccasin, Crimean at Dickinson, Preston at Langdon); 2, average of only six years (Preston at Dickinson and Edgeley); 3, average of only seven years (Preston at Newell); 4, average of only five years (Crimean at Highmore).

RESULTS AT AMARILLO, TEX.

The Amarillo Cereal Field Station is located in the center of the Texas Panhandle on a chocolate clay loam soil at an altitude of 3,676 feet. The average annual precipitation for the past 24 years is 21.2 inches. The experiments are conducted by the Office of Cereal Investigations in cooperation with the Amarillo Chamber of Commerce.

The data presented in Table XII and shown graphically in figure 12 cover the 11-year period from 1906, when the station was established, to 1916, inclusive. Three varieties of durum wheat belonging to two different groups have been grown throughout this period.

TABLE XII.—*Annual and average yields of three varieties of durum wheat and four varieties of common wheat grown at the Cereal Field Station, Amarillo, Tex., during the eleven years from 1906 to 1916, inclusive.*

[Data obtained in cooperation with the Amarillo Chamber of Commerce.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).											
		1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Average, 11 years, 1906 to 1916.
Durum:													
Kubanka—													
Saragolla	2228–I	7.6	8.5	15.3	6.5	2.7	11.1	14.0	8.5	12.7	11.7	5.5	9.5
Marouani	2235–I	5.3	10.4	16.8	5.7	2.8	11.6	11.0	3.9	15.5	14.3	4.2	9.2
Kubanka	1440	8.0	4.3	16.8	5.9	3.1	9.3	14.5	4.9	12.5	7.3	3.9	8.2
Common:													
Crimean (winter)—Turkey	1558	25.8	3.3	23.2	0	10.2	1.6	16.0	6.5	26.8	19.2	4.3	12.4
Mediterranean (winter)—Diehl-Mediterranean	1395–2	18.5	1.4	25.8	0	10.4	.4	14.3	4.8	23.0	18.0	6.7	11.2
Preston—Fretes	1596	5.1	10.7	19.5	8.5	3.6	9.0	14.8	4.5	11.5	9.5	3.4	9.1
Galgalos—Galgalos	2398	4.9	10.6	18.0	7.5	3.9	11.0	13.7	4.8	8.7	7.8	1.6	8.4

The yields of one representative of each of the hard red and the soft red groups of winter wheat and of each of two groups of spring wheat are tabulated for comparison. Climatic conditions are severe, and no yields are high. Winter varieties are better adapted and yield better than any spring wheat. Among the groups of spring wheat there is little choice from the standpoint of yield. The little difference that exists is in favor of the durum varieties, but it is in no way significant, nor is there any marked difference in the performance of the durum varieties. Saragolla and Marouani have a slight advantage over Kubanka, the variety which is best adapted at many of the northern stations. The two former varieties came from the Mediterranean district, but the latter is of Russian origin.

RESULTS AT HAYS, KANS.

The Fort Hays Branch Experiment Station, as shown in Table II (p. 15), is located on a silty clay loam soil at an altitude of 2,000 feet above sea level. During a 48-year period the normal annual rainfall has been 23.2 inches. The experiments there have been conducted cooperatively by the Kansas Agricultural Experiment Station and the Office of Cereal Investigations.

The data discussed in this paper are presented in Table XIII and are seen in graphic form in figure 12. They cover a period of 14 years, 1903 to 1916, inclusive.

TABLE XIII.—*Annual and average yields of two varieties of durum wheat and one variety of common wheat grown at the Fort Hays (Kans.) Branch Experiment Station during periods of varying length in the fourteen years from 1903 to 1916, inclusive.*

[Data obtained in cooperation with the Kansas Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).															
		1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Average. 5 years, 1912 to 1916.	Average. 14 years, 1903 to 1916.
Durum:																	
Kubanka—																	
Marouani	2235–I	....	....	....	....	....	....	....	....	....	12.2	3.8	7.0	11.8	5.2	8.0	.....
Kubanka	1440	0	1.7	0	2.2	0	8.4	0	18.1	0.1	8.2	2.1	1.2	7.8	3.5	4.6	3.8
Common:																	
Crimean (winter)—																	
Crimean	1437	33.2	10.7	5.9	5.2	4.3	26.1	0	17.6	2.2	17.7	15.6	22.6	6.3	37.0	19.8	14.6

The varieties tested throughout this period include only two, viz, Kubanka of the durum class and Crimean of the hard red winter group of common wheat. During this period the Crimean outyielded the Kubanka in the ratio of nearly 4 to 1, although the Crimean yield is only 14.6 bushels per acre. Tests during the last five years show that Marouani is better adapted than Kubanka. This part of Kansas is strictly a winter-wheat district, and spring wheat can not be profitably grown.

RESULTS AT AKRON, COLO.

The Akron Field Station of the Office of Dry-Land Agriculture, at Akron, Colo., lies at an altitude of 4,560 feet on a sandy loam soil. The average annual rainfall for the past 11 years was 19.7 inches. The experiments discussed herein were conducted by the Office of Cereal Investigations in cooperation with the Office of Dry-Land Agriculture of the Bureau of Plant Industry.

The results of the experiments are presented in Table XIV, and the principal data are shown in graphic form in figure 12. The

data are for the nine years from 1908 to 1916, inclusive. Yields are shown for 11 durum varieties tested during seven of these years and of four for all nine years. The most striking fact is the close agreement in yield of the best durum varieties and the Crimean winter wheat. The average yield of the Crimean is reduced by its complete failure in 1909. This was due, in part, to a treatment of the seed with formaldehyde which was too severe, resulting in a poor stand, which entirely winterkilled.

Among the spring wheats, the ordinary Fife and Bluestem varieties do not yield well at Akron, so the Fife group is represented by Ghirka Spring, and in the last four years by Marquis also. The Bluestem group is absent. The Preston group is represented by Erivan from the Caucasus region. Neither Ghirka Spring nor Erivan is able to compete with the best durum varieties in yield. From the records made by the Marquis in the four years since it was included in the test, it may prove to be more nearly equal to the durums than any other spring common varieties. From the data now available, however, the durums are the best spring wheats to grow at this station.

TABLE XIV.—*Annual and average yield of eleven varieties of durum wheat and four varieties of common wheat grown at the Akron Field Station, Akron, Colo., during periods of varying length in the nine years from 1908 to 1916, inclusive.*

[Data obtained in cooperation with the Office of Dry-Land Agriculture.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).											
											Average.		
		1908	1909	1910	1911	1912	1913	1914	1915	1916	7 years, 1908 to 1914.	7 years, 1910 to 1916.	9 years, 1908 to 1916.
Durum:													
Pelissier—Pelissier	1584	24.7	23.6	15.8	10.6	35.6	10.5	26.6	31.6	14.4	21.1	20.7	21.5
Kubanka—													
Arnautka	4064	.....	.....	19.5	15.7	37.3	10.6	25.0	27.6	11.4	.....	21.0	.....
Do	1493	26.9	20.8	16.6	10.6	27.5	10.5	27.6	27.9	10.7	20.1	18.7	19.9
Beloturka	1520	31.1	19.4	19.9	8.0	21.1	10.6	19.5	26.7	11.4	18.5	16.7	18.6
Kubanka	1440	26.8	9.3	17.1	9.0	25.1	5.1	20.7	27.6	12.9	16.2	16.8	17.1
Yellow Gharnovka	1444	32.8	25.1	15.0	10.8	34.2	5.3	22.5	.....	.....	20.9	.....	.....
Gharnovka	1447	29.1	20.9	13.1	9.3	36.5	3.3	23.7	.....	.....	19.3	.....	.....
Kubanka	1354	27.2	18.0	21.3	11.7	19.8	13.6	22.7	.....	.....	19.2	.....	.....
Marouani	1593	22.9	14.2	19.3	10.6	19.0	14.1	24.0	.....	.....	17.7	.....	.....
Velvet Don—Velvet Don	1445	33.3	21.1	13.5	10.0	33.3	7.3	25.3	.....	.....	20.5	.....	.....
Kahla—Purple	3024	24.8	20.8	15.3	7.9	33.0	10.0	21.2	.....	.....	19.0	.....	.....
Common:													
Crimean(winter)—Crimean	1436	19.1	0	36.3	17.9	33.1	12.6	28.3	26.6	20.5	21.3	25.0	21.6
Fife—Ghirka Spring	1517	20.6	23.8	18.8	8.5	23.4	14.0	19.3	22.6	7.5	18.3	16.3	17.6
Marquis	3641	.....	.....	.....	.....	.....	7.5	19.7	26.5	11.8	.....	.....	.....
Preston—Erivan	2397	19.3	26.3	15.2	11.9	20.7	12.0	19.3	19.5	7.8	17.8	15.2	16.9

Considering only the durum wheats, Pelissier leads in the first 7-year average and the 9-year average and almost ties with Arnautka for first place in the second 7-year average. In the Kubanka group a pure line, Arnautka 6P1 (C. I. No. 4064), a selection of Arnautka

(C. I. No. 1494), leads in the 7-year period in which it was grown. The unselected Arnautka (C. I. No. 1493) stands next to Pelissier in the 9-year period. In the first 7-year period, however, Yellow Gharnovka of the Kubanka group is the highest yielder, followed by Velvet Don, type of a different group, and Arnautka (C. I. No. 1493) ranks third. The Yellow Gharnovka and Velvet Don were discarded at the end of the seven years in spite of their high average rank, but Beloturka and Kubanka were continued. The low average yield of Kubanka is in part due to a poor stand obtained in 1909, which resulted in a very low yield that year. Omitting 1909, which was also the year of failure for winter wheat, the difference in yield during the eight remaining years between the three varieties of the Kubanka group is hardly significant. The Pelissier exceeds the best of the Kubanka group in these eight years by 1.6 bushels, but in turn is exceeded in yield by Crimean winter wheat by 3.1 bushels per acre.

RESULTS AT NORTH PLATTE, NEBR.

The North Platte substation is located in the valley of the South Platte River, just above the junction of the North and South Forks. It lies at an altitude of 3,000 feet and is located on the porous clay-loam soil known as loess. The normal annual rainfall is 18.9 inches. The cereal experiments were conducted independently by the Nebraska Agricultural Experiment Station, and the results are made available here through the courtesy of the director and his associates.

TABLE XV.—*Annual and average yields of six varieties of durum wheat and three varieties of common wheat grown at the North Platte (Nebr.) substation during periods of varying length in the eleven years from 1906 to 1916, inclusive.*

[Data used by courtesy of the Nebraska Agricultural Experiment Station.]

Class, group, and variety.	Yield per acre (bushels).													
												Average.		
	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	5 years, 1906 to 1910.	5 years, 1912 to 1916.	11 years, 1906 to 1916.
Durum:														
Kubanka—														
Gharnovka	22.6	31.4	32.2	28.0	3.4	0	6.7	7.2	3.0	24.1	20.0	23.5	12.2	16.2
Kubanka No. 1	.....	.....	.....	.....	.....	.....	3.2	7.7	3.9	25.1	19.5	.....	11.9	.....
Kubanka [a]	18.6	33.0	30.3	26.5	3.5	0	6.5	7.9	2.3	21.6	19.9	22.4	11.6	15.5
Kahla—														
Black Don	22.8	28.6	32.5	27.2	3.5	.....	.....	.....	.....	.....	.....	22.9	.....	.....
Kahla	.....	.....	.....	.....	.....	.....	6.7	9.8	2.9	19.2	18.4	.....	11.4	.....
Velvet Don—Velvet Don	23.4	29.0	30.8	25.5	2.5	0	5.1	8.9	4.0	.....	.....	22.2	.....	.....
Common:														
Crimean (winter)—Turkey [b]	.....	.....	.....	.....	.....	.....	9.9	16.8	8.0	37.3	38.3	.....	22.1	.....
Fife—Marquis	.....	.....	.....	.....	.....	.....	4.6	6.8	4.3	20.2	17.4	.....	10.7	.....
Preston—Preston [c]	.....	.....	.....	.....	.....	.....	3.0	3.0	3.0	6.6	16.2	.....	6.4	.....

[a] Average yields from two plats.
[b] Average yields from nine plats in the rotations of the Office of Dry-Land Agriculture Investigations.
[c] This variety was grown under the name Scotch Fife.

The experiments with durum wheat date from 1906. The data are given in Table XV and the principal facts graphically in figure 12.

The results show that there is little difference in the yielding power of several different varieties under the prevailing conditions at North Platte. The vicissitudes attendant upon grain growing, however, are clearly shown by the yields in the 5-year period, 1912 to 1916, inclusive, which are only about half as large as those in the 5-year period, 1906 to 1910, inclusive. Comparison of durum yields with those of other wheats can be made only in the second 5-year period. The yield of Turkey is nearly double that of the durum varieties. Marquis does not quite equal the yield of the poorest durum and falls 1.5 bushels below that of the best durum. Preston is much poorer than Marquis. To summarize, winter wheat of the Crimean group ranks first, while the durums outyield any spring common wheat so far tried.

The differences in yield between the different durum varieties are scarcely large enough to be significant. The Kubanka group outyields either Kahla or Velvet Don, and the Gharnovka outyields Kubanka within the group.

RESULTS AT ARCHER, WYO.

The Cheyenne Field Station at Archer, Wyo., is located on a fairly sandy loam containing some gravel. The altitude is almost exactly 6,000 feet above sea level. The normal rainfall is only 14.2 inches. These records are mostly from Fort D. A. Russell at Cheyenne, 9 miles distant, where conditions probably are slightly more favorable than at Archer. The conditions of high altitude and northern latitude allow only a short growing season, and this, combined with the low rainfall, makes crop growing somewhat difficult. The experiments are conducted by the Office of Cereal Investigations in cooperation with the Wyoming State Board of Farm Commissioners.

The results of experiments conducted with wheat in the four years 1913 to 1916, inclusive, or since the establishment of the station, are shown in Table XVI, and the principal results graphically in figure 12. Here, as at Akron, the number of durum varieties is large, no less than 14 having been tested during all or a part of this period. Here again there is a close agreement between the yields of the hard red winter wheats and the best durums, the Turkey having a slightly higher yield. The best durum varieties again outyield the Erivan and also the Marquis by small quantities. The Haynes Bluestem is decidedly outclassed by the durums.

From a study of Table XVI it is evident that no less than five varieties of the Kubanka group have outyielded the representatives of the other groups of spring wheat. This is true in both the 3-year and the 4-year periods, and four of the outstanding varieties are the same in

both periods. These four are Kubanka (C. I. No. 1516), Beloturka, Pererodka, and Kubanka (C. I. No. 1440), named in the order of their 4-year rank. Pelissier, which was the highest yielding variety at Akron, Colo., makes a fair yield at Archer, but ranks eighth in the 3-year average and sixth in the 4-year average. From the data at hand the durums of the Kubanka group seem to be the spring wheats best adapted for this district.

TABLE XVI.—*Annual and average yields of fourteen varieties of durum wheat and four varieties of common wheat grown at the Cheyenne Field Station, Archer, Wyo., during periods of varying length in the four years from 1913 to 1916, inclusive.*

[Data obtained in cooperation with the Wyoming State Board of Farm Commissioners.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).					
		1913	1914	1915	1916	Average. 3 years, 1913 to 1915.	Average. 4 years, 1913 to 1916.
Durum:							
Kubanka—							
Kubanka	1516	7.1	13.0	27.6	6.5	15.9	13.6
Beloturka	1520	7.7	11.9	28.9	5.1	16.2	13.4
Pererodka	1350	8.3	12.8	26.0	5.4	15.7	13.1
Kubanka	1440	7.5	12.5	25.6	5.8	15.2	12.9
Arnautka	1493	7.2	12.3	23.8	6.1	14.4	12.4
Marouani	1593	7.9	11.5	21.5	7.6	13.6	12.1
Arnautka	4064	6.4	10.7	23.6	6.9	13.6	11.9
Yellow Gharnovka	1444	7.8	11.5	25.9	.....	15.1	.....
Gharnovka	1447	7.5	12.3	24.1	.....	14.6	.....
Kubanka	1354	7.7	12.8	22.1	.....	14.2	.....
Pelissier—							
Pelissier	1584	8.7	11.6	22.6	5.9	14.3	12.2
Saragolla	2228	6.7	10.3	18.8	.....	11.9	.....
Velvet Don—Velvet Don	1445	8.6	10.8	24.4	.....	14.6	.....
Kahla—Purple	3024	7.5	10.5	22.8	.....	13.6	.....
Common:							
Crimean (winter)—Turkey	1571	10.0	7.9	32.0	10.0	16.6	15.0
Preston—Erivan	2397	9.4	9.5	22.0	7.5	13.6	12.1
Fife—Marquis	3641	9.0	8.4	20.9	5.4	12.8	10.9
Bluestem—Haynes	2874	4.4	9.0	11.7	5.0	8.4	7.5

RESULTS AT HIGHMORE, S. DAK.

The Highmore substation of the South Dakota Agricultural Experiment Station is located on a glacial clay loam soil at an altitude above sea level of 1,890 feet. The average annual rainfall has been 16.7 inches during the last 22 years. The cereal experiments were conducted by the South Dakota Agricultural Experiment Station in cooperation with the Office of Cereal Investigations.

The experiments were begun in 1902. The data obtained are shown in Table XVII, and the principal facts are presented graphically in figure 12. No less than 26 durum varieties were tested in the first three or four years. Only nine of these, all in the Kubanka group, were carried for a long period of time. Cropping conditions are sometimes precarious in this locality. Almost complete failures are recorded in 1911 and 1912, and the yields in 1910 and 1913 were very low

TABLE XVII.—*Annual and average yields of twenty-seven varieties of durum wheat and six varieties of common wheat grown at the Highmore (S. Dak.) substation during periods of varying length in the fifteen years from 1902 to 1916, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Class, group, and variety	C. I. No.	Yield per acre (bushels).															Average.			
		1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	4 years, 1902 to 1905.	10 years, 1903 to 1912.	12 years, 1905 to 1916.	4 years, 1913 to 1916.
DURUM.																				
Kubanka:																				
Kubanka	1440	22.3	15.2	23.8	23.2	26.7	28.7	22.7	17.0	8.0	0	1.1	2.0	19.7	33.3	12.2	21.1	16.6	16.2	16.8
Arnautka	(1)	....	17.8	16.8	38.7	20.0	22.5	25.0	12.7	1.7	0	.8	2.8	8.9	38.3	7.5	....	15.6	14.9	14.4
Kubanka	1516	....	10.7	23.3	28.5	31.2	26.8	27.5	14.8	13.0	0	.7	4.2	....	....	....	....	17.7	....	....
Do	1354	....	12.8	20.3	27.0	27.2	29.7	23.8	19.5	12.2	0	.8	3.3	22.2	30.0	....	....	17.3	....	....
Pererodka	1350	....	15.9	21.2	28.3	28.5	27.3	22.0	17.2	6.2	0	0	....	....	....	....	....	16.7	....	....
Arnautka	1537	....	16.2	18.0	36.0	22.0	22.7	25.0	15.8	2.0	0	0	....	....	....	....	....	15.8	....	....
Beloturka	1513	....	14.0	12.3	35.8	22.8	24.2	27.8	12.5	2.0	0	1.6	4.4	....	....	....	....	15.3	....	....
Kubanka	1541	....	10.0	23.2	26.7	25.5	21.7	22.5	10.7	8.3	0	0	....	....	....	....	....	14.9	....	....
Arnautka	4072	....	....	....	36.7	23.8	23.8	26.0	14.2	5.0	0	0	....	8.9	30.0	....	....	....	....	....
Taganrog	1570	24.3	18.5	13.3	35.0	....	....	....	....	....	....	....	....	....	....	....	22.8	....	....	....
Berdiansk	1586	29.4	15.8	12.7	33.0	....	....	....	....	....	....	....	....	....	....	....	22.7	....	....	....
Kubanka	2094	22.3	16.7	23.3	26.5	22.8	....	....	....	....	....	....	....	....	....	....	22.2	....	....	....
Yellow Gharnovka	2096	29.6	18.2	10.5	26.7	....	....	....	....	....	....	....	....	....	....	....	21.3	....	....	....
Argentine	1569	20.0	17.0	10.7	33.3	....	....	....	....	....	....	....	....	....	....	....	20.3	....	....	....
Kubanka	2234	20.0	13.5	22.3	24.3	....	....	....	....	....	....	....	....	....	....	....	20.0	....	....	....
Yellow Gharnovka	1444	23.2	18.7	11.3	25.2	....	....	....	....	1.8	0	.4	3.3	29.3	33.3	10.0	19.6	....	....	19.0
Gharnovka	1443	24.0	15.5	13.5	24.2	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....
Marouani	1593	22.3	11.7	14.0	29.2	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....
Gharnovka	1447	22.2	14.7	11.8	24.0	....	....	....	....	....	....	....	....	....	....	....	18.2	....	....	....
Acme	5284	....	....	....	....	....	....	....	....	....	....	....	....	30.0	31.7	22.0	....	....	....	....
Velvet Don: Velvet Don	1445	29.3	18.8	12.5	27.2	....	....	....	....	....	....	....	....	....	....	....	22.0	....	....	....
Pelissier:																				
Medeah	1597	23.7	14.0	11.0	31.8	....	....	....	....	....	....	....	....	....	....	....	20.1	....	....	....
Mohamed ben Bachir	2087	16.8	11.8	14.7	36.7	....	....	....	....	....	....	....	....	....	....	....	20.0	....	....	....
Pelissier	1584	26.5	17.8	14.0	20.8	....	....	....	....	....	....	....	....	....	....	....	19.8	....	....	....
Do	2086	22.2	20.2	12.3	22.5	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....
Kahla:																				
Kahla	1595	17.3	11.2	11.3	35.8	....	....	....	....	....	....	....	....	....	....	....	18.9	....	....	....
Do	2088	14.4	9.0	13.7	32.0	....	....	....	....	....	....	....	....	....	....	....	17.3	....	....	....
COMMON.																				
Crimean (winter):																				
Kharkof	1442	....	....	....	....	....	....	....	....	....	....	3.7	2.1	12.5	31.7	39.2	....	....	....	21.4
Fife:																				
Marquis	3641	....	....	....	....	....	....	....	....	....	....	....	12.7	13.3	33.3	6.3	....	....	....	16.4
Power	2989	....	....	....	20.5	14.8	12.5	16.1	16.5	10.3	0	0	6.3	8.7	26.7	5.0	....	....	11.5	11.7
Ghirka Spring	1517	....	14.0	8.0	26.0	22.0	15.0	4.8	17.7	6.2	0	2.4	6.5	11.3	16.7	7.2	....	11.1	10.9	10.4
Preston: Preston	3081	....	....	....	25.5	20.3	18.7	11.0	17.5	6.8	.3	.5	6.5	12.0	35.8	7.0	....	....	13.5	15.3
Bluestem: Haynes (Minn. No. 51)	1505	....	....	....	22.8	17.0	16.0	16.3	15.8	9.5	0	0	7.7	4.8	22.5	1.7	....	....	11.2	9.2

[1] Yields of Arnautka C. I. No. 1493 are shown for 1903 to 1910; C. I. No. 1547 for 1911 to 1913; C. I. No. 4072 for 1914; C. I. No. 4064 for 1915 and 1916.

The record of the yields is favorable to the durum wheats in comparison with spring common wheat. The best of the latter in a 12-year average has been Preston, but its yield of 13.5 bushels is 1.4 bushels below that of Arnautka and 2.7 bushels below that of Kubanka. Power and Haynes fall 2 and 2.3 bushels, respectively, below Preston.

During the last four years the Marquis has been included in the experiment. In 4-year average yield it outranks Preston by 1.1 bushels and Arnautka by 2 bushels. It falls behind Kubanka by only 0.4 of a bushel. Yellow Gharnovka durum, reintroduced into the test, has proved the best yielder of all, however, in this period, its yield of 19 bushels exceeding that of Kubanka by 2.2 bushels and that of Marquis by 2.6 bushels. Kharkof, a hard red winter wheat of the Crimean group, also has been grown during this 4-year period, and its yield of 21.4 bushels exceeds even that of the Yellow Gharnovka by 2.4 bushels.

From present indications it may be concluded that the Crimean wheats will outyield spring wheats here when they survive the winters. This station is about the present northern limit of winter-wheat production in central and eastern South Dakota. Good durum varieties will regularly outyield any spring variety now known, but Marquis and Preston are both good yielding varieties of spring common wheat in central South Dakota.

Among the durum wheats, Kubanka has given the highest yields of any variety tested in the 10-year and 12-year periods. In the 10-year period, three lots of Kubanka are among the four highest yielders, the other being Pererodka, which ranked third. In the last four years, however, Kubanka was outyielded by Yellow Gharnovka by 2.2 bushels. In the first 4-year period, 1902–1905, inclusive, three varieties, Taganrog, Berdiansk, and Yellow Gharnovka, all outyielded any Kubanka. Kubanka (C. I. No. 2094) also outyielded Kubanka (C. I. No. 1440), which was continued in the experiments, whereas the four varieties previously named were all dropped. Of the several lots or pure strains of Arnautka included in the tests, none has exceeded Kubanka consistently for any series of years. A selection of Kubanka (C. I. No. 1516), recently named Acme and assigned C. I. No. 5284, has been included in the experiments during only the last three years. This pure line has shown remarkable rust resistance, and as a result has outyielded all other wheats grown in the 3-year period from 1914 to 1916. In 1916 it was grown also at Brookings, S. Dak., where it outyielded all other spring wheats.

RESULTS AT EUREKA, S. DAK.

The Eureka substation of the South Dakota Agricultural Experiment Station is located on the remains of an old terminal moraine, the resulting soil being a stony sandy loam. The altitude is 1,884 feet, and the average annual rainfall during the last seven years has been 16.4 inches. The experiments were conducted independently by the South Dakota Agricultural Experiment Station until 1912, and since then in cooperation with the Office of Cereal Investigations.

The data presented in Table XVIII and shown graphically in figure 12 cover a period of eight years, from 1909 to 1916, inclusive. Only three varieties, one durum and two spring common wheats, were grown throughout the period. The 8-year average yield of the Kubanka durum is nearly double that of Preston and more than double that of Dakota Bluestem. The same facts are apparent in comparing the average yields of the same varieties in the last three years, 1914 to 1916, inclusive. During this period, however, Marquis was grown. This variety produced a yield 5.7 bushels higher than that of Preston and only 3.3 bushels lower than that of Kubanka.

TABLE XVIII.—*Annual and average yields of one variety of durum wheat and three varieties of common wheat grown at the Eureka (S. Dak.) substation during periods of varying length in the eight years from 1909 to 1916, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).									
		1909	1910	1911	1912	1913	1914	1915	1916	Average, 3 years, 1914 to 1916.	Average, 8 years, 1909 to 1916.
Durum:											
Kubanka—Kubanka	1440	22.5	10.7	0	0	15.1	9.3	42.9	10.3	20.8	13.9
Common:											
Fife—Marquis	3641	.....	.....	.....	.....	.....	9.7	35.5	7.4	17.5	.....
Preston—Preston	3081	12.5	3.8	0	1.5	7.7	10.7	22.9	1.7	11.8	7.6
Bluestem—Dakota	3083	10.1	2.3	0	5.2	8.7	6.6	18.5	.4	8.5	6.5

Beyond question, the durum wheats are better adapted to this district than are any spring common wheats yet known. Although no other variety than Kubanka has been grown, the evidence from other stations similarly located indicates Kubanka to be the best variety under these conditions.

RESULTS AT NEWELL, S. DAK.

The Belle Fourche Experiment Farm is located at an altitude of 2,900 feet on the Belle Fourche Reclamation Project, northeast of the Black Hills. The soil is a heavy clay with shale subsoil, known geologically as Pierre clay and popularly as gumbo. The average annual rainfall is only 14.1 inches, as shown by the records of eight years. The station is maintained by the Office of Western Irrigation Agriculture, and the cereal experiments are conducted by the Office of Cereal Investigations in cooperation with that office, and since 1912 in cooperation with the South Dakota Agricultural Experiment Station. Though the station is irrigated, the experiments discussed were conducted under dry-land conditions on ground wholly above the ditch.

The combination of high altitude and northern location permits only a rather short growing season. Add to this the low rainfall and it is seen that cropping under dry-land conditions is somewhat handicapped. The results since the station was established in 1908 are shown in Table XIX and the principal data graphically in figure 12. The difficulties experienced are indicated by the complete failures in 1911 and 1912 and the very low yields of spring varieties in 1910 and 1914.

TABLE XIX.—*Annual and average yields of five varieties of durum wheat and five varieties of common wheat grown on the Belle Fourche Experiment Farm, Newell, S. Dak., during periods of varying length in the nine years from 1908 to 1916, inclusive.*

[Data obtained in cooperation with the Office of Western Irrigation Agriculture and, since 1912, with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).											
											Average.		
		1908	1909	1910	1911	1912	1913	1914	1915	1916	4 years, 1913 to 1916.	7 years, 1910 to 1916.	9 years, 1908 to 1916.
Durum:													
Kubanka—													
Kubanka	1516	23.8	22.6	5.3	0	0	19.1	9.6	54.5	19.7	25.7	15.5	17.2
Arnautka	1493	22.3	22.6	8.3	0	0	17.1	9.5	54.9	14.8	24.1	14.9	16.6
Pererodka	1350	22.5	23.2	5.2	0	0	16.7	9.7	58.2	13.7	24.6	14.8	16.6
Kubanka	1440	24.9	21.4	7.4	0	0	15.6	[a]9.5	54.4	13.8	23.3	14.4	16.3
Yellow Gharnovka	1444	22.7	20.9	5.0	0	0	16.5	7.4	54.0	.....	.....	.....	[b]15.7
Common:													
Crimean (winter)—													
Kharkof	1442	25.4	40.3	22.7	0	0	38.6	28.7	63.8	14.2	36.3	24.0	26.0
Preston—Preston	3081	.....	.....	9.2	0	0	19.5	7.2	46.9	5.8	19.9	12.6	.....
Fife—													
Marquis	3276	.....	.....	.....	.....	.....	16.8	8.0	50.9	8.1	21.0	.....	.....
Power	3025	18.5	17.3	10.6	0	0	16.6	5.1	43.4	6.5	17.9	11.7	13.1
Bluestem—Haynes (Minn. No. 169)	3020	18.3	13.8	9.0	0	0	14.1	5.1	42.0	5.6	16.7	10.9	12.0

[a] Computed from yields of Kubanka, C. I. No. 1516.
[b] Average for only 8 years, 1908 to 1915, inclusive.

The data presented show clearly certain facts. Hard red winter wheat of the Crimean group outyields any spring variety in all years except 1916, when Kharkof was outyielded by Kubanka and Arnautka durums. In average yields the Kharkof outranks Kubanka by fully 50 per cent.

The five durum spring wheats, all of the Kubanka group, excel any spring common wheat by yields that are significant. In the four years during which it has been grown Marquis is the best yielder of the spring common wheats. It outyields Preston, the highest yielding variety in the 7-year period, by more than 1 bushel, but falls 4.7 bushels per acre behind the best Kubanka. In short, the durum varieties are the best spring wheats for the Belle Fourche district.

The Kubanka (C. I. No. 1516) leads in yield by an annual average of about half a bushel in the 9-year period. This quantity is not significant, and there is little choice among the four durum varieties which were grown throughout this period. No varieties of any other groups of durum wheat were under experiment during the periods of years shown.

RESULTS AT EDGELEY, N. DAK.

The Edgeley substation of the North Dakota Agricultural Experiment Station is located on a light sandy loam soil with a shale subsoil. It lies at an altitude of 1,468 feet and has an average annual rainfall of 18 inches for 15 years. The experiments were conducted independently by the North Dakota Agricultural Experiment Station, and the data presented are from the published annual reports of the substation. Experiments were begun in 1903 and have been published up to and including 1913.

The data found in Table XX were obtained from the annual reports of the Edgeley substation of the North Dakota Agricultural Experiment Station for the years 1903 to 1913, inclusive (Thompson, 1904–1914), and the principal facts are portrayed graphically in figure 12. Eleven-year records are given for five durum varieties representing two different groups and for one variety in each of two groups of spring common wheat. No continued attempt was made to grow winter wheat. The tabulated average yields show that all five of the durums outyielded the best spring common varieties in this period by 5 to 6 bushels per acre, which is equivalent to 30 per cent or more.

TABLE XX.—*Annual and average yields of five varieties of durum wheat and four varieties of common wheat grown at the Edgeley (N. Dak.) substation during periods of varying length in the eleven years from 1903 to 1913, inclusive.*

Class, group, and variety.	C. I. No.	Edgeley No.	Yield per acre (bushels).											Average.	
			1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	6 years, 1908 to 1913.	11 years, 1903 to 1913.
Durum:															
Kubanka—															
Arnautka	3693	5	19.4	31.3	42.1	27.2	13.8	13.5	27.6	2.3	1.6	32.9	25.2	17.2	21.5
Pererodka	1350	7	21.4	25.0	42.1	23.8	11.0	13.7	29.0	3.4	2.4	31.3	25.1	17.5	20.7
Gharnovka	1443	9	20.6	30.8	39.0	23.8	12.5	12.9	28.5	2.8	2.4	22.6	28.6	16.3	20.4
Kubanka	1440	6	18.2	21.5	43.4	21.4	13.2	11.3	28.5	3.4	2.0	33.4	25.1	17.3	20.1
Velvet Don—Velvet Don.	1445	8	20.3	35.2	43.2	19.3	15.6	11.3	29.6	2.3	2.0	23.0	21.5	15.0	20.3
Common:															
Preston—Preston	2958	188	....	....	....	....	....	9.6	17.3	7.9	3.2	21.6	26.9	14.4	.....
Bluestem—Haynes	3021	2	15.1	11.6	30.3	15.6	6.5	9.6	19.4	6.7	2.0	26.4	21.5	14.3	15.0
Fife—Rysting	3022	3	19.7	11.6	29.4	12.3	6.2	10.1	20.3	6.2	1.6	21.7	25.2	14.2	14.9

The most striking fact in Table XX is the very close agreement of average yields for long periods. The average yields of the five durum varieties in the 11-year period range only from 20.1 bushels to 21.5 bushels per acre. The yield of Haynes is 15 bushels and of Rysting 14.9 bushels in the same period. In the 6-year period, 1908–1913, inclusive, Preston, Rysting, and Haynes vary only 0.2 bushel in average yield.

In the Edgeley district a durum wheat is decidedly the best wheat to grow. This conclusion is borne out also by the fact that the greatest density of durum production is in that section of the State. Among the five varieties tested, Arnautka has proved slightly the best adapted, outyielding Kubanka by 1.4 bushels in all 11 years. This result is in accord with those obtained at Brookings, S. Dak., and Crookston, Minn., discussed in the subhumid prairie section.

RESULTS AT LANGDON, N. DAK.

The Langdon substation of the North Dakota Agricultural Experiment Station is located on a black clay-loam soil at an altitude of 1,615 feet. The average annual rainfall in a 4-year period has been 17.9 inches. The substation is operated independently by the North Dakota Agricultural Experiment Station, and the results obtained have been published in annual reports, from which source they are presented here (Stewart, 1910–1914).

Data are available for only the five years, 1909 to 1913, inclusive. These are found in Table XXI, and the principal ones in figure 12. The results are all definitely and significantly in favor of the durum wheats.

TABLE XXI.—*Annual and average yields of six varieties of durum wheat and three varieties of common wheat grown at the Langdon (N. Dak.) substation during periods of varying length in the five years from 1909 to 1913, inclusive.*

Class, group, and variety.	C. I. No.	Yield per acre (bushels).							
							Average.		
		1909	1910	1911	1912	1913	4 years, 1909 to 1912.	4 years, 1910 to 1913.	5 years, 1909 to 1913.
Durum:									
Kubanka—									
Arnautka	1494	30.8	15.3	29.4	34.7	21.6	27.6	25.2	26.4
Gharnovka	1443	25.2	13.6	29.6	35.7	24.3	26.0	25.6	25.7
Pererodka	1350	29.8	12.0	25.5	32.7	21.7	25.0	23.0	24.3
Kubanka	1349	25.0	11.2	27.0	31.3	23.1	23.6	23.2	23.5
Yellow Gharnovka	1444	24.2	9.6	24.2	30.7	.....	22.2	.....	.....
Velvet Don—Velvet Don	1445	16.8	9.7	27.6	24.1	.....	19.6	.....	.....
Common:									
Preston—"Velvet Chaff," No. 13	.....	.....	7.5	19.2	32.3	18.7	.....	19.4	.....
Fife—Glyndon (Minn. No. 163)	2873	20.5	10.7	17.1	27.2	21.5	18.9	19.1	19.4
Bluestem—Haynes (Minn. No. 169)	2874	19.4	8.0	17.5	27.5	22.8	18.1	19.0	19.0

The best average yield of any spring common wheat is slightly lower than the lowest average yield of any durum wheat in the same period of years. Among the common varieties, Glyndon has the best 5-year average, 19.4 bushels per acre, while for the same period the average yield of Arnautka is 26.4 bushels per acre. All three of the standard spring common varieties are in close agreement in average yield during the 4-year and 5-year periods.

At Langdon there is more difference between the yields of the different durum wheats than is usually the case. All four of the varieties in the Kubanka group distinctly outyield Velvet Don. Within the Kubanka group, Arnautka (C. I. No. 1494) leads, outyielding Kubanka (C. I. No. 1349) by nearly 3 bushels per acre. These results substantiate further the results obtained at other stations in the Red River and Big Sioux valleys and territory adjacent thereto, showing the Arnautka variety to be best adapted to that section.

RESULTS AT DICKINSON, N. DAK.

The Dickinson substation of the North Dakota Agricultural Experiment Station is located on the border of the Heart River valley on a soil varying from sandy loam to clay loam. The elevation is 2,453 feet, and the average annual precipitation has been 15.7 inches in a 24-year period. The experiments were conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations.

The results will be found in Table XXII, and the principal data in graphic form in figure 12. Experiments have been in progress for 11 years, but the wheat crop of 1912 was destroyed by hail. Here, as elsewhere in the State, the durum varieties have outyielded all varieties of spring common wheat by quantities that are significant. Kubanka and Arnautka are the only durums grown throughout the 10-year period. Here Kubanka has proved a slightly better yielder than Arnautka. In a 5-year period the two excel all other durums. During a 7-year period they in turn have been outyielded by a pure-line selection of Kubanka (C. I. No. 1440). This selection, first known as Kubanka No. 8, is now known as Cereal Investigations No. 4063. In this period it had an average yield of 3.3 bushels greater than the parent Kubanka. In the last 4 years of the test all the varieties were exceeded in yield by the new and more rust-resistant variety, distributed as "D1" but now named Monad.[1]

Among the spring common wheats, Fife leads in yield, with Preston next and Bluestem last. Only Rysting and Haynes have been grown throughout the period. In the last four years Marquis has produced

[1] This name is derived from mona, the Greek word for one, plus *d*, which stands for durum. This variety was obtained in Russia by Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station, and was further selected by him at Fargo.

an average yield of 21.1 bushels, compared with 17.7 from Rysting, a gain of 3.4 bushels. In the same period, however, the yields of the four durums range from 25.5 bushels to 30.2 bushels per acre, so that Marquis does not equal durum in this district.

TABLE XXII.—*Annual and average yields of seven varieties of durum wheat and five varieties of common wheat grown at the Dickinson (N. Dak.) substation during periods of varying length from 1906 to 1916, inclusive.*[a]

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).												
												Average.		
		1906	1907	1908	1909	1910	1911	1913	1914	1915	1916	4 years, 1913 to 1916.	5 years, 1906 to 1910.	9 years, 1906–1911 and 1913–1915.
Durum:														
Kubanka—														
Monad	3320	.....	.....	.....	.....	.....	.....	30.9	13.6	50.1	26.2	30.2	.....	.....
Kubanka	4063	.....	.....	.....	43.2	19.9	3.5	31.2	13.0	51.5	17.4	28.3	.....	.....
Do	1440	28.8	36.0	23.5	33.7	14.9	3.8	26.7	14.2	46.8	16.6	26.1	27.4	24.5
Arnautka [b]	1494	24.3	26.4	22.8	37.0	23.4	[c]3.2	30.9	11.6	44.8	14.6	25.5	26.8	23.9
Pererodka	1350	27.3	28.4	18.8	36.0	23.0	.....	.....	.....	.....	.....	.....	26.7	.....
Arnautka	1493	24.3	28.4	24.0	36.5	15.7	.....	.....	.....	.....	.....	.....	25.8	.....
Yellow Harnovka	1444	22.5	28.6	17.6	33.7	15.1	.....	.....	.....	.....	.....	.....	23.5	.....
Common:														
Fife—														
Marquis	3641	.....	.....	.....	.....	.....	.....	24.2	14.0	32.8	13.5	21.1	.....	.....
Rysting	3022	22.0	17.6	22.3	33.0	20.7	7.7	28.1	12.4	25.6	4.5	17.7	23.1	19.4
Preston—Preston	3081	.....	.....	.....	.....	23.0	9.7	25.2	12.9	24.8	8.5	17.9	.....	.....
Bluestem—Haynes	2874	21.1	14.0	21.4	30.0	[d]13.1	8.6	24.8	8.3	22.9	3.1	14.8	19.9	16.7
Crimean (winter)—														
Beloglina	1543	.....	.....	.....	.....	.....	.....	9.1	9.2	0	18.7	9.3	.....	.....

[a] Crop of 1912 destroyed by hail.
[b] For 1906 to 1910, Arnautka (C. I. No. 1494); in 1913 to 1916, Arnautka 6P1 (C. I. No. 4064), a pure-line selection from C. I. No. 1494, made at Akron, Colo.
[c] Not grown; yield computed from yield of Kubanka (C. I. No. 1400.)
[d] Destroyed by hail; yield computed from Crossbred Bluestem (C. I. No. 3314).

RESULTS AT WILLISTON, N. DAK.

The Williston substation of the North Dakota Agricultural Experiment Station is on a fine sandy loam soil in the valley of the Missouri River at an altitude of 1,875 feet. The normal annual rainfall is 14.9 inches. The experiments at Williston have been conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations.

The results of varietal trials with durum wheat and representative varieties of common wheat are presented in Table XXIII, and the leading data are shown graphically in figure 12. Six varieties of durum wheat, five of which belong to the Kubanka group, have been grown in periods varying from four to nine years. Velvet Don was outyielded by all varieties of the Kubanka group grown in the 6-year period from 1908 to 1912, inclusive. Kubanka and Arnautka are the only durum varieties grown throughout the 9-year period.

Kubanka has slightly outyielded Arnautka. It has excelled also in all periods all other durum varieties except a pure-line selection of Taganrog (C. I. No. 1570). This selection has been given Cereal Investigations No. 5295 and is here named Buford, to commemorate the Buford-Trenton Reclamation Project, in which the Williston substation is located. This wheat has outyielded all others included in Table XXIII during each of the last four years, with an average yield of 44.1 bushels, which is 1.6 bushels greater than that of Kubanka.

TABLE XXIII.—*Annual and average yields of six varieties of durum wheat and five varieties of common wheat grown at the Williston (N. Dak.) substation during periods of varying length in the nine years from 1908 to 1916, inclusive.*

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).												
											Average.			
		1908	1909	1910	1911	1912	1913	1914	1915	1916	4 years, 1913 to 1916.	6 years, 1908 to 1913.	8 years, 1909 to 1916.	9 years, 1908 to 1916.
Durum:														
Kubanka—														
Buford	5295	.....	.....	.....	.....	.....	35.0	54.6	49.4	37.2	44.1	.....	.....	.....
Kubanka	1440	12.6	39.1	11.0	8.9	51.0	33.0	53.8	47.3	36.0	42.5	25.9	35.0	32.5
Arnautka	3693	15.6	37.4	6.1	8.2	49.7	34.7	47.2	45.5	37.4	41.2	25.3	33.3	31.3
Gharnovka	1447	15.8	35.5	9.3	10.5	46.0	34.8	.....	.....	.....	.....	25.3	.....	.....
Pererodka	1350	12.8	34.8	9.5	7.3	48.3	33.7	.....	.....	.....	.....	24.4	.....	.....
Velvet Don—Velvet Don	1445	15.6	36.8	3.7	8.9	43.3	25.0	.....	.....	.....	.....	22.2	.....	.....
Common:														
Fife—														
Marquis	3641	.....	.....	.....	.....	.....	29.0	52.5	40.6	35.0	39.3	.....	.....	.....
Power	3697	13.1	34.0	17.1	11.1	44.7	28.7	51.3	45.1	31.8	39.2	24.8	33.0	30.8
Bluestem—Dakota	3083	16.7	35.1	11.1	10.9	42.3	30.7	47.5	44.6	28.5	37.8	24.5	31.3	29.7
Preston—Preston	3698	.....	26.2	13.4	12.7	44.7	25.0	46.3	43.4	35.0	37.4	.....	30.8	.....
Crimean (winter)—														
Beloglina	1543	.....	40.0	9.9	26.5	0	7.8	10.0	12.8	34.2	16.2	.....	17.7	.....

The durum wheats have outyielded the leading varieties of Fife, Bluestem, Preston, and Crimean winter wheat in all the periods in which comparisons can be made. The lead of Kubanka over Power Fife, its nearest competitor in the common wheats, in the 8-year and 9-year periods is 2 bushels and 1.7 bushels, respectively, quantities which may be called fairly significant. It is probable that conditions in the valley where the station is located are slightly more favorable to common wheat than they are on the upland soil, which includes most of the farm land in that section of the State.

These results, covering a long period of years, together with those from Dickinson, N. Dak., and Highmore, Eureka, and Newell, S. Dak., show rather conclusively that Kubanka durum wheat is the variety best adapted to the central and western parts of North and South Dakota. A single year's test at Mandan, N. Dak., further supports this conclusion.

RESULTS AT MOCCASIN, MONT.

The Judith Basin, or Fergus County, substation, is located on a dark clay loam with a gravelly subsoil. The station has an altitude of 4,228 feet, and the average annual precipitation in the last 18 years has been 16.7 inches. Experiments there are conducted cooperatively by the Montana Agricultural Experiment Station and the Office of Cereal Investigations.

Data are presented in Table XXIV on experiments with durum wheat and the leading varieties of common wheat since 1908. The principal data are shown in graphic form in figure 12. Eleven varieties of durum wheat, belonging to four different groups, have been under experiment, though only two varieties have been grown continuously since 1908. The experimental crop of 1912 was destroyed by hail, so that the results of only eight years are available.

TABLE XXIV.—*Annual and average yields of eleven varieties of durum wheat and four varieties of common wheat grown at the Judith Basin substation, Moccasin, Mont., during periods of varying length in the nine years from 1908 to 1916, inclusive.*[a]

[Data obtained in cooperation with the Montana Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).										
		1908	1909	1910	1911	1913	1914	1915	1916	Average. 4 years, 1908 to 1911.	Average. 7 years, 1909–1911 and 1912–1916.	Average. 8 years, 1908–1911 and 1912–1916.
Durum:												
Pelissier—Pelissier	1584	10.0	41.0	10.5	28.3	32.0	26.5	42.2	28.7	22.5	29.9	27.4
Kubanka—												
Kubanka	1440	5.0	37.8	8.8	33.0	30.7	23.0	40.7	28.7	21.2	29.0	26.0
Pererodka	1350	5.0	36.7	12.7	36.0	32.0	25.3	40.1	.....	22.6	.....	.....
Yellow Gharnovka	1444	15.0	39.3	8.2	27.7	32.8	25.0	39.2	.....	22.5	.....	.....
Beloturka	1520	9.5	40.3	6.5	29.0	30.0	25.2	40.1	.....	21.3	.....	.....
Arnautka	1494	10.0	33.0	7.6	31.7	.....	.....	.....	.....	20.6	.....	.....
Do	1493	10.0	36.7	10.0	25.0	.....	.....	.....	.....	20.4	.....	.....
Gharnovka	1447	5.0	35.8	10.0	30.3	.....	.....	.....	.....	20.3	.....	.....
Taganrog	1570	3.3	36.3	16.3	24.3	.....	.....	.....	.....	20.0	.....	.....
Kahla—Purple	3024	10.0	39.0	8.5	26.0	.....	.....	.....	.....	20.9	.....	.....
Velvet Don—Velvet Don	1445	7.5	32.3	6.1	26.0	.....	.....	.....	.....	18.0	.....	.....
Common:												
Crimean (winter)—												
Kharkof	1583	.....	32.8	48.0	41.3	31.1	30.3	61.3	0	.....	35.0	.....
Fife—												
Marquis	3641	.....	.....	.....	.....	33.5	23.7	42.3	32.9	.....	.....	.....
Rysting	3022	2.5	29.0	13.0	27.0	26.7	23.0	40.7	25.0	.....	26.3	23.4
Preston—Preston	2958	.....	31.0	13.5	25.0	29.2	22.4	41.6	[b]27.1	.....	27.1	.....
Bluestem—Haynes	3021	5.0	30.0	11.7	21.0	.....	.....	.....	.....	17.0	.....	.....

[a] The crop of 1912 was destroyed by hail.

[b] Yield of Preston, C. I. No. 3081, substituted.

The yields of all durum varieties are in rather close agreement. Pelissier has exceeded or equaled in yield all other varieties in all periods. Kubanka has ranked very close to Pelissier throughout. In the first four years, Kubanka was slightly excelled by Pererodka, Yellow Gharnovka, and Beloturka, in the order named.

Of the common wheats, Kharkof, of the Crimean group, outyielded even Pelissier in the 7-year period by 5 bushels, or 16 per cent. The leading spring common wheats are outyielded by the durums in quantities that are significant. Fife and Preston outyield Bluestem. Marquis, however, which was not included in the experiments until 1913, has an average yield of 33.1 bushels during the four years, compared with 28.8 bushels from Rysting Fife, 30.8 bushels from Kubanka, and 32.3 bushels from Pelissier. In these four years, therefore, it has outyielded not only the Fife wheat, but the two best durums as well. The durums, especially Pelissier, unquestionably are good wheats for this section. Marquis is as good and the hard red winter wheats are better than either.

Here, as at Akron, Colo., Pelissier has proved the best adapted of all durum wheats tested. These experiments, together with those at Archer, Wyo., and the result of a single year at Havre, Mont., indicate that Pelissier is the best-yielding durum wheat yet obtained for the drier western plains area having an altitude of 4,000 feet or more.

RESULTS AT BRANDON, MANITOBA.

The Brandon Experiment Farm is located on a sandy loam soil. Its altitude is 1,176 feet, and its average annual rainfall is 13 inches, according to a 9-year record. The station is maintained by the Canadian Department of Agriculture, and the data presented in Table XXV have been taken from the published annual reports (Canada Experimental Farms, 1896–1908).

TABLE XXV.—*Annual and average yields of three varieties of durum wheat and two varieties of common wheat grown on the Brandon (Manitoba) Experiment Farm during periods of varying length in the eleven years from 1895 to 1905, inclusive.*

Class, group, and variety.	Yield per acre (bushels).												
												Average.	
	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	2 years, 1904 and 1905.	11 years, 1895 to 1905.
Durum:													
Goose(Arnautka)	42.2	38.5	26.5	45.4	50.4	31.5	42.0	44.6	46.3	53.3	49.0	51.2	42.7
Yellow Ghar-novka	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.0	54.0	49.5	.....
Mahmoudi	.....	.....	.....	.....	.....	.....	.....	.....	.....	44.6	46.6	45.6	.....
Common:													
Fife—Red Fife	49.0	26.6	35.4	36.4	38.5	21.4	36.4	31.0	24.4	36.6	45.3	41.0	34.6
Preston—Preston	48.4	18.8	27.2	32.4	38.6	17.0	31.0	25.0	23.6	33.0	52.0	42.5	31.5

A variety of durum wheat was included in the experiments from 1895 to 1905. It was grown under the name Goose, but is probably the Arnautka variety. Two other varieties were included in the last

two years. The resulting data from these and from representative varieties of the Fife and Preston groups are shown in graphic form in figure 12. In the 11-year period, the durum variety is seen to outyield Red Fife by 8.1 bushels and Preston by 11.2 bushels per acre.

RESULTS AT INDIAN HEAD, SASKATCHEWAN.

The Indian Head Experiment Farm has an average annual precipitation of 19.4 inches, based on a record covering 10 years. It is maintained by the Canadian Department of Agriculture, and the results given in Table XXVI are taken from the published annual reports (Canada Experimental Farms, 1896–1908).

TABLE XXVI.—*Annual and average yields of three varieties of durum wheat and two varieties of common wheat grown on the Indian Head (Saskatchewan) Experiment Farm, during periods of varying length in the thirteen years from 1895 to 1907, inclusive.*

Class, group, and variety.	Yield per acre (bushels.)													Average.	
	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	4 years, 1904 to 1907.	13 years, 1895 to 1907.
Durum:															
Goose (Arnautka)	33.4	45.8	27.2	34.4	31.6	20.0	63.0	51.6	36.2	43.1	54.6	51.6	31.6	45.2	40.3
Mahmoudi	....	....	....	....	....	....	....	....	46.0	43.4	51.3	49.0	25.6	42.3	.....
Yellow Gharnovka	....	....	....	....	....	....	....	....	.....	41.7	52.0	52.6	29.3	43.9	.....
Common:															
Preston—Preston	45.6	41.8	36.0	42.2	33.4	15.4	57.4	48.6	43.2	39.6	35.3	39.3	23.3	34.4	38.5
Fife—Red Fife	45.0	41.4	37.8	44.4	39.6	30.4	57.0	29.4	38.5	43.1	37.6	43.6	12.0	34.1	38.4

The experiments extend from 1895 to 1907, a period of 13 years. The same varieties are included as at Brandon, viz, a durum called Goose, probably Arnautka, with Preston and Red Fife, two spring common wheats. As at Brandon, two other durum varieties, Mahmoudi and Yellow Gharnovka, are included during the last five and four years, respectively. Arnautka outyielded the other two durums in the short period during which all were grown. In the 13-year period it outyielded Preston by 1.8 bushels and Red Fife by 1.9 bushels per acre. A market for durum wheat was not developed in Canada, so the wheat was not recommended for general cultivation by the Dominion Cerealist, and finally the varieties were discontinued from experimental tests.

RESULTS IN THE ARID BASIN AND COASTAL AREAS.

This geographic division includes most of the territory west of the Rocky Mountains. In the basin area are included the States and portions of States between the Rockies and the Sierra Nevada and

Cascade Ranges, excluding the humid portions of northern Idaho and northern Washington. The semiarid coastal area comprises only the two great interior valleys of California. The Willamette Valley of Oregon and the Puget Sound section of Washington are humid.

The chief agricultural lands of the basin area mostly lie at altitudes of 4,000 to 6,000 feet. This includes most of the dry-farmed districts in Utah, Idaho, Nevada, and Oregon, often called the Great Basin. It comprises the Salt Lake Basin of Utah, the Snake River Basin of Idaho, the Humboldt Basin of northern Nevada, the Harney Basin of southeastern Oregon, and the plateau region of central and southern Oregon, as well as territory adjacent to but perhaps not strictly included in any of these. The Columbia Basin of eastern Washington and north-central Oregon has an altitude of 1,000 to 2,000 feet. The San Joaquin and Sacramento Valleys of California lie much lower, the lower end of each reaching sea level and the upper portions being but a few hundred feet higher.

All these areas are characterized by low precipitation. Most of the rain falls during the autumn, winter, and spring months instead of during the summer, as in the Great Plains area. The seasonal rainfall is small in proportion to the total precipitation. For this reason, among others, winter wheats are more profitable and more extensively grown than spring-sown wheats. Crop production is governed almost wholly by the quantity and distribution of the annual precipitation. From Table II it will be seen that the annual rainfall of these stations, omitting only Chico, Cal., ranges from 9.5 to 13.5 inches.

Summer fallowing the land or allowing the fields to lie fallow in alternate years is the common farm and station practice in these areas. Summer tillage of the fallow to prevent the growth of weeds and volunteer grain conserves much of the moisture which falls in the year of fallow to help grow the crop in the succeeding year.

The soils of much of this area are of volcanic origin and are light in texture. Reference again to the data in Table II shows the soil at all six of the stations named to be either a sandy loam or a sandy clay loam.

Owing to the altitude, the growing season is short in much of this territory and early varieties are desirable. This also is another reason why winter varieties are more satisfactory. Even in the California valleys, with their low altitude and extremely long growing season, the intense heat and drought of midsummer make early varieties as important there as elsewhere.

The results from six stations in the arid basin and coastal areas are given in this bulletin. These stations are well scattered geograph-

ically, as will be seen from figure 13. They are also representative of the greatest extremes of altitude and precipitation, as will be noted from Table II (p. 15). Their altitude ranges from less than 100 feet to nearly 6,000 feet, and the precipitation ranges from 9.5 to 23.6 inches per annum.

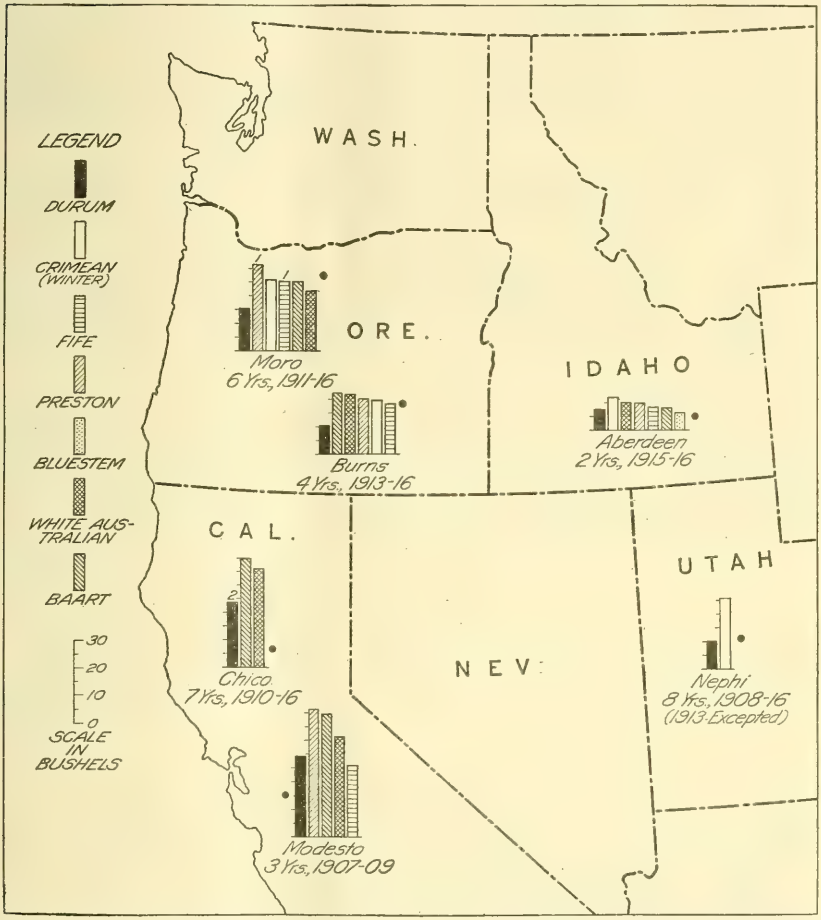

FIG. 13.—Diagram showing the location of six stations in the Great Basin and western coast areas and the average yield of the leading variety of durum wheat and the leading variety of each of several different groups of common wheat at each station during the periods of years indicated: 1, Average of only four years (Preston and Fife groups at Moro); 2, average of all varieties of durum wheat grown at Chico.

Durum wheats are not grown commercially anywhere in these areas. The leading wheats are the hard red winter varieties of the Crimean group and a number of soft red and soft white wheats, both winter and spring. None of them except the members of the Crimean group are varieties grown in the Great Plains area.

RESULTS AT NEPHI, UTAH.

The Nephi substation is located in Juab Valley in the eastern part of Juab County, Utah, near the summit of the Levan Ridge. This is a ridge of land a few miles in width, extending transversely across the valley floor south of the town of Nephi. The soil is a sandy clay loam. The altitude at the town of Nephi is 5,580 feet. The exact altitude of the substation on the ridge, 6 miles distant, is not known, but is thought to be nearly 6,000 feet. The average annual precipitation is 13.5 inches in a 17-year period. The experiments at Nephi were conducted cooperatively by the Utah Agricultural Experiment Station and the Office of Cereal Investigations.

The experiments began in 1908 and cover a period of eight years, no durum wheats having been grown in 1913. The results of varietal experiments with four durum wheats and one winter common wheat are shown in Table XXVII. The principal data are presented graphically in figure 13. One of the durum varieties was tested for only five years, but data on all of the others are available for the full 8-year period.

TABLE XXVII.—*Annual and average yields of four varieties of durum wheat and one variety of common wheat grown at the Nephi (Utah) substation during periods of varying length in the nine years from 1908 to 1916, inclusive.*[a]

[Data obtained in cooperation with the Utah Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).									
										Average.	
		1908	1909	1910	1911	1912	1914	1915	1916	5 years, 1908 to 1912.	8 years, 1908–1912 and 1914–1916.
Durum:											
Kubanka—Kubanka	1440	10.0	11.5	2.0	7.3	5.3	15.7	18.2	15.0	7.2	10.2
Pelissier—											
Adjini	1594	12.5	7.8	2.2	5.5	4.1	19.0	15.3	12.7	6.4	9.9
Mohamed ben Bachir	2087	8.0	8.8	2.2	6.0	6.3	18.5	14.2	14.2	6.3	9.8
Kahla—Kahla	2088	12.0	9.7	3.2	7.0	6.6	.....	.....	.....	7.7	.....
Common:											
Crimean (winter)—Crimean	1437	30.3	18.7	20.3	26.7	19.5	40.3	29.4	23.0	23.1	26.0

[a] Durum wheats were not grown in 1913.

In the five years from 1908 to 1912, inclusive, Kahla, a black-glumed variety, slightly outyielded the other three durums. It was not grown longer. In the eight years, Kubanka excelled the two little-known varieties of the Pelissier group by a small fraction of a bushel. The durum yields are all low, however, the best annual yield recorded being only 19 bushels per acre. The winter precipitation and short growing season both favor winter wheats. It is not surprising, therefore, to find the 8-year average yield of Crimean hard red winter

wheat to be 26 bushels, or an increase of 150 per cent over that of Kubanka. Durum wheats were also tested at this station from fall sowing, but the yields obtained were no larger than from spring sowing.

RESULTS AT ABERDEEN, IDAHO.

The Aberdeen substation is located in the Snake River Plains of southern Idaho on a sandy clay-loam soil containing some volcanic-ash material. The altitude is 4,400 feet. The average annual precipitation in the past four years has been only 9.5 inches, the lowest recorded for any of the stations west of the Rocky Mountains. The substation is maintained cooperatively by the Idaho Agricultural Experiment Station and the Office of Cereal Investigations.

The results obtained at Aberdeen are found in Table XXVIII and the principal data in graphic form in figure 13. Data on durum wheats are available for only the last two years. These wheats are compared with a representative variety from each of six different groups of spring wheat and the Crimean group of winter wheat. The average yields of all varieties are low in this 2-year period. Only three out of nine varieties exceed 10 bushels per acre. The yields of the durum are below the general average, being exceeded, or at least equaled, by five of the six spring common varieties. Although data for only two years are not conclusive, there is little reason for expecting the durum varieties to be worthy of being grown in the Snake River Basin.

TABLE XXVIII.—*Annual and average yields of five varieties of durum wheat and seven varieties of common wheat grown at the Aberdeen (Idaho) Branch Experiment Station during 1915 and 1916.*

[Data obtained in cooperation with the Idaho Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).			Class, group, and variety.	C. I. No.	Yield per acre (bushels).		
		1915	1916	Average.			1915	1916	Average.
Durum:					Common—Continued.				
Kubanka—					White Australian—				
Arnautka	4064	7.2	8.3	7.8	Pacific Bluestem	4067	9.0	12.3	10.7
Do	1493	4.5	.....	.....	Preston—Fretes	1596	10.8	9.7	10.3
Kubanka	1516	6.3	8.7	7.5	Fife—Marquis	3276	6.3	11.3	8.8
Beloturka	1520	5.4	.....	.....	Baart—Early Baart	1697	7.5	9.7	8.6
Pelissier—Pelissier	1584	6.3	.....	.....	Little Club—Little Club	4066	7.2	8.3	7.8
Common:					Bluestem—Haynes	2874	5.4	8.0	6.7
Crimean (winter)—									
Kharkof	1442	21.1	3.5	12.3					

The 2-year average yield of the Crimean variety Kharkof also is low, although its 12.3 bushels is the highest average of all. This is lower than observation and experience show may reasonably be expected from these wheats in this section.

RESULTS AT BURNS, OREG.

The Harney Branch Experiment Station is located near the town of Burns in the bed of an ancient lake now known as the Harney Valley. The soil varies from a silt loam to a very fine sandy loam. The altitude of the station is 4,100 feet, which is about that of the valley floor and lower than that of the plateau of south-central Oregon. The average annual precipitation during the past 12 years has been 11.7 inches. The station is conducted cooperatively by the Oregon Agricultural Experiment Station and the Office of Cereal Investigations.

The station was established in 1912, and the first crop was grown in 1913. Data covering the experiments of four years are given in Table XXIX. The principal facts are illustrated in figure 13. Four durum varieties were grown during the first three years, but only one of these, Kubanka, C. I. No. 1354, was continued in 1916. In the 3-year period, Kubanka, C. I. No. 1354, was outyielded by all three of the other durums, the lead of Marouani being 3.7 bushels. In the same period Marouani was exceeded by all five varieties of common wheat in quantities ranging from 5 to 10 bushels per acre. The same fact holds true in the 4-year average, where Kubanka is the only durum and the yields of the common wheat exceed that of Kubanka by 8 to 11.5 bushels per acre.

TABLE XXIX.—*Annual and average yields of four varieties of durum wheat and seven varieties of common wheat grown at the Harney Branch Experiment Station, Burns, Oreg., during periods of varying length in the four years from 1913 to 1916, inclusive.*

[Data obtained in cooperation with the Oregon Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).					
						Average.	
		1913	1914	1915	1916	3 years, 1913 to 1915.	4 years, 1913 to 1916.
Durum:							
Kubanka—							
Marouani	1593	22.7	7.2	16.0	.....	15.3	.....
Yellow Gharnovka	1144	22.8	6.0	13.3	.....	14.0	.....
Kubanka	2246	17.0	8.0	15.3	.....	13.4	.....
Do	1354	13.2	6.0	15.7	7.7	11.6	10.7
Common:							
Baart—Early Baart	1697	28.3	18.2	26.2	16.1	24.2	22.2
White Australian—Pacific Bluestem	4067	32.0	16.7	23.6	15.6	24.1	22.0
Crimean (winter)—Turkey	1558	26.0	19.3	30.7	4.0	25.3	20.0
Fife—							
Ghirka Spring	1517	25.3	15.7	20.5	13.4	20.5	18.7
Marquis	.....	.....	9.3	21.3	11.3	.....	.....
Preston—Preles	1596	28.0	13.3	20.0	.....	20.4	.....

Among the common wheats, Early Baart and Pacific Bluestem, two soft white wheats, outyielded the red-kerneled spring wheats of the Great Plains area. The hard red winter wheats are a somewhat

precarious crop in this district and are not able to outyield the best spring varieties of common wheat. Durum varieties are evidently not suitable for growing in this valley.

RESULTS AT MORO, OREG.

The Eastern Oregon Dry-Farming Substation is located in Sherman County, on the rolling hills of the Columbia Basin, at an average altitude of 1,800 feet. The soil is a silt loam. The average annual rainfall has been 11.3 inches in the past 11 years. The station is operated cooperatively by the Oregon Agricultural Experiment Station and the Office of Cereal Investigations.

The yields obtained from 1911 to 1916, inclusive, are shown in Table XXX, and the principal facts are portrayed in figure 13. Only two durum varieties have been grown throughout this period. Their yields, while good, still are lower than those of any variety of common wheat shown. This is true in both the 4-year and the 6-year periods. The Turkey hard red winter wheat is the best of all, closely followed by Early Baart and Koola. These latter two varieties are both bearded wheats, the first one with white, the other with red kernels. Durum wheats are not likely to become important in the Columbia Basin on the basis of the showing made.

TABLE XXX.—*Annual and average yields of two varieties of durum wheat and six varieties of common wheat grown at the Eastern Oregon Dry-Farming Substation, Moro, Oreg., during periods of varying length in the six years from 1911 to 1916, inclusive.*

[Data obtained in cooperation with the Oregon Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).							
		1911	1912	1913	1914	1915	1916	Average. 4 years, 1913 to 1916.	Average. 6 years, 1911 to 1916.
Durum:									
Kubanka—									
Kubanka	1440 1516	11.0	16.2	16.0	21.5	18.0	29.5	21.3	18.7
Blé Noir	2511–2	3.5	7.5	18.0	18.3	23.6	37.2	24.3	18.0
Common:									
Preston—Koola	2203–2	.....	.....	25.8	24.5	33.2	44.6	32.0	.....
Crimean (winter)—Turkey	1558	9.0	20.6	24.0	27.5	20.6	55.0	31.8	26.1
Baart—Early Baart	1697	14.5	19.0	25.0	26.0	26.6	41.0	29.7	25.4
Little Club—Little Club	4068	13.1	22.6	19.6	19.2	26.0	42.3	26.8	23.8
Fife—Marquis	4158	.....	.....	22.1	22.5	23.1	35.3	25.8	.....
White Australian—Pacific Bluestem	4067	11.7	20.1	19.4	20.9	24.0	37.3	25.4	22.2

RESULTS AT CHICO, CAL.

The Chico Plant Introduction Garden is located in the Sacramento Valley, at an altitude of 189 feet, on a sandy loam soil containing some gravel. The normal annual precipitation is 23.6 inches, according to the records of 45 years. The garden is maintained by the Office of Foreign Seed and Plant Introduction of the Bureau of

Plant Industry, and the cereal experiments are conducted in cooperation therewith by the Office of Cereal Investigations. Data resulting from experiments conducted in the years 1910 to 1916, inclusive, are given in Table XXXI, and the principal facts are shown graphically in figure 13.

TABLE XXXI.—*Annual and average yields of ten varieties of durum wheat and two varieties of common wheat grown at the Plant Introduction Garden, Chico, Cal., during periods of varying length in the seven years from 1910 to 1916, inclusive.*

[Data obtained in cooperation with the Office of Foreign Seed and Plant Introduction.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).								
		1910	1911	1912	1913	1914	1915	1916	Average. 2 years, 1910 and 1911.	Average. 7 years, 1910 to 1916.
Durum:										
Kubanka—										
Kubanka	2246	19.7	36.3	.....	.....	.....	.....	.....	28.0	.....
Yellow Gharnovka	2096	9.6	36.6	.....	.....	26.2	.....	.....	23.1	.....
Marouani	1593	[a]10.7	34.6	.....	.....	.....	.....	.....	22.7	.....
Kubanka	1440	[a]8.5	29.6	.....	[a]29.5	.....	.....	.....	19.1	.....
Do	2221	2.5	32.3	.....	.....	.....	.....	.....	17.4	.....
Unnamed	1595	.....	.....	21.3	.....	21.3	18.0	22.0	.....	.....
Arnautka	1494	.....	.....	25.0	32.3	19.0	.....	.....	.....	.....
Cavarna	2575	.....	.....	30.0	29.7	.....	.....	.....	.....	.....
Velvet Don—Velvet Don	2227	20.0	33.3	.....	.....	.....	.....	.....	26.7	.....
Kahla—										
Unnamed	2235–2	.....	.....	26.3	34.8	27.7	.....	20.1	.....	.....
Average of all durums	.....	11.8	33.8	25.7	31.6	23.6	18.0	21.1	.....	23.7
Common:										
Baart—Early Baart	1697	39.3	90.6	27.5	45.7	30.2	19.2	27.5	65.0	40.0
White Australian—White Australian	3019	28.0	65.5	[b]31.5	[c]44.7	[b]34.7	18.6	32.0	46.8	36.4

[a] Average of two plats. [b] Average of six plats. [c] Average of seven plats.

All varieties are fall sown at Chico, and all are grown on summer-fallowed land. No less than 10 different durum varieties have been tested during the seven years, but none of them for more than three years consecutively. For this reason it is almost impossible to arrive at comparable average yields. However, only a glance is needed to show that the durums are all greatly outyielded by the two representative varieties of common wheat. This is true, in spite of the fact that some good yields were obtained from the durum varieties. In the comparison made between yields of durum and varieties of two groups of common wheat in figure 13, the average yield of all varieties of durum wheat grown is used.

RESULTS AT MODESTO, CAL.

The Modesto substation was located in the lower San Joaquin Valley at an altitude of 90 feet. The soil is the sandy loam characteristic of the valley. The average annual precipitation is 10.5

inches on the basis of 44-year records. The substation was established to conduct experiments with cereals and was maintained cooperatively by the California Agricultural Experiment Station and the Office of Cereal Investigations.

TABLE XXXII.—*Annual and average yields of six varieties of durum wheat and four varieties of common wheat grown at the Modesto (Cal.) substation during periods of varying length in the three years from 1907 to 1909, inclusive.*

[Data obtained in cooperation with the California Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).				
					Average.	
		1907	1908	1909	2 years, 1908 and 1909.	3 years, 1907 to 1909.
Durum:						
Kubanka—						
Marouani	2235	9.7	44.7	33.3	39.0	29.3
Kubanka	2221	.....	26.8	26.5	26.7	.....
Do	2246	.....	30.8	21.8	26.3	.....
Yellow Gharnovka	2096	.....	31.8	18.0	24.9	.....
Velvet Don—Velvet Don	2247	7.4	32.8	14.2	23.5	18.1
Pelissier—Medeah	1597	.....	32.8	13.3	23.1	.....
Common:						
Preston—Fretes	1596	16.2	67.3	56.0	61.7	46.5
Baart—Propo	1970	9.0	69.3	55.0	62.2	44.4
White Australian—White Australian	3019	13.1	51.3	44.0	47.7	36.1
Fife—Power	2989	6.7	33.2	39.1	36.2	26.3

The yields obtained in experiments continued for three years, 1907 to 1909, inclusive, are shown in Table XXXII, and the principal facts are shown graphically in figure 13. Six varieties of durum wheat, belonging to three separate groups, were included during two years, and two of them during all three years. Four varieties of common wheat, two with hard red kernels and two with soft white kernels, were compared with the durum varieties. Among the durums, Marouani easily takes first place. Here, as at Chico, however, only a glance is needed to show the marked superiority of the common wheats. As at other points west of the Rocky Mountains, durum varieties are not the best adapted wheats for growing in California.

SUMMARY OF RESULTS.

The average yield of the highest yielding durum wheat at each of the 30 stations discussed in this bulletin is presented in Table XXXIII. In parallel columns is shown the average yield of the best variety in each of the groups of common wheat, both winter and spring, which were grown at the stations in the same period of years. The length of the periods is shown in the second column.

TABLE XXXIII.—*Average yields of the highest yielding variety of durum wheat and the highest yielding variety in one or more of six different groups of common wheat grown at thirty experiment stations in the western United States and Canada under humid, semiarid, and arid conditions during some of the twenty-two years from 1895 to 1916, inclusive.*

SECTION 1.—YIELD PER ACRE OF THE BEST VARIETY IN EACH GROUP (BUSHELS).

Area and station.	Number of years grown.	Durum.	Crimean (winter).	Fife.	Preston.	Bluestem.	White Australian.	Baart.
Prairie (subhumid area):								
McPherson, Kans.	6	12.6	23.2	.....	.....	.....	.....	.....
Manhattan, Kans.	3	12.6	40.1	[a] 7.5	[a] 4.5	[a] 6.6	.....	.....
Lincoln, Nebr.	1	16.5	33.2	.....	.....	.....	.....	.....
Ames, Iowa.	5	21.5	34.5	[b] 26.7	24.9	22.7	.....	.....
Brookings, S. Dak.	12	19.7	[c] 23.9	12.7	16.2	12.1	.....	.....
Ashland, Wis.	4	23.0	[b] 23.6	20.0	[b] 18.2	24.9	.....	.....
St. Paul, Minn.	4	31.6	[b] 46.0	36.5	34.9	30.9	.....	.....
Crookston, Minn.	5	25.7	.....	23.8	20.5	20.1	.....	.....
Fargo, N. Dak.	7	35.9	.....	24.7	[d] 23.9	28.3	.....	.....
Great Plains (semiarid area):								
Amarillo, Tex.	11	9.5	12.4	.....	9.1	.....	.....	.....
Hays, Kans.	14	3.8	14.6	.....	.....	.....	.....	.....
Akron, Colo.	9	21.5	21.6	17.6	16.9	.....	.....	.....
North Platte, Nebr.	5	12.2	22.1	10.7	6.4	.....	.....	.....
Archer, Wyo.	4	13.6	15.0	10.9	12.1	7.5	.....	.....
Highmore, S. Dak.	12	16.2	[e] 17.8	11.5	13.5	11.2	.....	.....
Eureka, S. Dak.	8	13.9	.....	[b] 17.5	7.6	6.5	.....	.....
Newell, S. Dak.	9	17.2	26.0	13.1	[f] 12.6	12.0	.....	.....
Edgeley, N. Dak.	11	21.5	.....	14.9	[g] 14.4	15.0	.....	.....
Langdon, N. Dak.	5	26.4	.....	19.4	[d] 19.4	19.0	.....	.....
Dickinson, N. Dak.	10	24.5	[d] 9.3	19.4	[g] 17.4	16.7	.....	.....
Williston, N. Dak.	8	35.0	17.7	33.0	30.8	31.3	.....	.....
Moccasin, Mont.	7	29.9	35.0	26.3	27.1	[d] 17.0	.....	.....
Brandon, Manitoba.	11	42.7	.....	34.6	31.5	.....	.....	.....
Indian Head, Saskatchewan.	13	40.3	.....	38.4	38.5	.....	.....	.....
Western basin and coast (arid area):								
Nephi, Utah.	8	10.2	26.0	.....	.....	.....	.....	.....
Aberdeen, Idaho.	2	7.8	12.3	8.8	10.3	6.7	10.7	8.6
Burns, Oreg.	4	10.7	20.0	18.7	[b] 20.4	.....	22.0	22.2
Moro, Oreg.	6	18.7	26.1	[d] 25.8	[d] 32.0	.....	22.2	25.4
Chico, Cal.	7	[h] 23.7	.....	.....	.....	.....	36.4	40.0
Modesto, Cal.	3	29.3	.....	26.3	46.5	.....	36.1	44.4

SECTION 2.—YIELD PER ACRE EXPRESSED AS A PERCENTAGE OF THE YIELD OF DURUM.

Prairie (subhumid area):								
McPherson, Kans.	6	100	184.2	.....	.....	.....	.....	.....
Manhattan, Kans.	3	100	318.0	[a] 61.5	[a] 36.9	[a] 54.1	.....	.....
Lincoln, Nebr.	1	100	201.0	.....	.....	.....	.....	.....
Ames, Iowa.	5	100	160.5	[b] 126.5	115.8	105.6	.....	.....
Brookings, S. Dak.	12	100	[c] 108.1	64.5	82.3	61.4	.....	.....
Ashland, Wis.	4	100	[b] 100.8	87.0	[b] 77.8	108.2	.....	.....
St. Paul, Minn.	4	100	[b] 136.8	115.5	110.3	97.7	.....	.....
Crookston, Minn.	5	100	.....	92.6	79.8	78.2	.....	.....
Fargo, N. Dak.	7	100	.....	68.8	[d] 66.6	78.9	.....	.....
Great Plains (semiarid area):								
Amarillo, Tex.	11	100	130.5	.....	95.8	.....	.....	.....
Hays, Kans.	14	100	384.3	.....	.....	.....	.....	.....
Akron, Colo.	9	100	100.5	81.9	78.6	.....	.....	.....
North Platte, Nebr.	5	100	181.0	87.7	52.4	.....	.....	.....
Archer, Wyo.	4	100	110.2	80.2	89.0	55.2	.....	.....
Highmore, S. Dak.	12	100	[e] 130.0	71.0	83.4	69.2	.....	.....
Eureka, S. Dak.	8	100	.....	[b] 84.2	54.6	46.8	.....	.....
Newell, S. Dak.	9	100	151.1	76.2	[f] 81.3	69.8	.....	.....
Edgeley, N. Dak.	11	100	.....	69.3	[g] 83.7	69.8	.....	.....
Langdon, N. Dak.	5	100	.....	73.5	[d] 77.0	72.0	.....	.....
Dickinson, N. Dak.	10	100	[d] 35.6	79.2	[g] 84.9	68.2	.....	.....
Williston, N. Dak.	8	100	50.6	94.3	88.0	89.4	.....	.....
Moccasin, Mont.	7	100	117.1	88.0	90.7	[d] 75.6	.....	.....
Brandon, Manitoba.	11	100	.....	81.0	73.8	.....	.....	.....
Indian Head, Saskatchewan.	13	100	.....	95.3	95.5	.....	.....	.....
Western basin and coast (arid area):								
Nephi, Utah.	8	100	254.8	.....	.....	.....	.....	.....
Aberdeen, Idaho.	2	100	157.7	112.8	132.1	85.9	137.2	110.2
Burns, Oreg.	4	100	186.8	174.8	[b] 175.8	.....	205.5	207.3
Moro, Oreg.	6	100	139.5	[d] 121.1	[d] 150.2	.....	118.7	135.8
Chico, Cal.	7	[h] 100	.....	.....	.....	.....	153.6	168.7
Modesto, Cal.	3	100	.....	89.8	158.6	.....	123.2	151.6

[a] Average for 2 years only.
[b] Average for 3 years only.
[c] Average for 10 years only.
[d] Average for 4 years only.
[e] Average for 5 years only.
[f] Avera e for 7 years only.
[g] Average for 6 years only.
[h] Average of all durum varieties grown.

Section 1 of Table XXXIII shows the actual average acre yields obtained from each wheat. Section 2 shows the same data expressed in percentages. The yield of the best durum variety is taken as 100 per cent in each case. The data in this table are the same as those shown graphically in figures 8, 12, and 13.

The actual performance is seen more readily in the first section of the table, where yields are given in bushels per acre. The comparative performance, which indicates in large measure the comparative value, is seen much more readily in the second section of the table, where the results are expressed in percentages. After the detailed presentation of these data in Tables III to XXXII, inclusive, only a brief summary seems necessary.

THE SUBHUMID PRAIRIE AREA.

In studying the summarized results from the nine stations in the subhumid prairie area, certain facts stand out plainly, as will be seen in Table XXXIII.

(1) In general, the durum wheats are not adapted to the humid conditions often obtaining in the eastern part of this area, but they do comparatively well in the subhumid northwestern part.

(2) In the southern part of the prairie area, which includes the eastern portions of Kansas and Nebraska, neither durum nor common spring wheats do well.

(3) Wherever the hard red winter wheats of the Crimean group can be grown they greatly outyield any spring wheat.

(4) In the northeastern portion of this area, under the conditions obtaining at Ashland, Wis., and St. Paul, Minn., winter wheat is reaching the northern limits of its present culture and is not so outstandingly superior. The durum wheats are equal in yield to some of the common wheats and poorer than others. The value of the durums will depend on the quality of their grain and the need which exists for their rust resistance.

(5) In the northwestern portion of this area, including the western part of Minnesota and the eastern parts of the Dakotas, the durum wheats have a much higher comparative value. They largely outyield the spring common wheats and nearly equal winter wheat in the districts where it can be grown at all.

(6) Of the varieties of durum wheat tested Arnautka is best adapted for growing in western Minnesota and the eastern portions of the Dakotas.

THE GREAT PLAINS AREA.

A study of the summarized results from 15 stations in the Great Plains area, shown in part in Table XXXIII, supports the following conclusions:

(1) Durum wheats produce very well in all but the southern part of this large area.

(2) No spring wheats do well in the southern part of the Great Plains.

(3) Wherever the hard red winter wheats of the Crimean group can be grown commercially they are better yielders than any spring wheat. In the higher and drier parts of the plains of Colorado and Wyoming and in central South Dakota their advantage is very small.

(4) In the central and northern parts of this area, wherever spring wheat is commercially important, durum exceeds spring common wheat in yield almost without exception. Usually this is by a large margin, of 10 to 30 per cent, but occasionally by as little as 5 per cent.

(5) Of all the varieties of durum wheat tested in this area, the Kubanka is best adapted to all the varying conditions. It is most suitable for central and western North and South Dakota and eastern Montana, at altitudes ranging from 1,800 to 4,000 feet. The Arnautka is slightly better adapted to the more humid eastern part of the Northern Plains with altitudes ranging from 1,000 to 1,800 feet. The Pelissier is a better yielder in the western and drier sections at altitudes of 4,000 to 6,000 feet.

(6) A number of pure-line selections of durum wheat are proving better adapted to the local conditions where they were developed than are the older standard varieties. Three which differ appreciably from the standard varieties from which they were selected have been named. Five of these races appear to be of sufficient value to be tested under a wide range of conditions. They are as follows: Acme (C. I. No. 5284), a selection from Kubanka (C. I. No. 1516) made at Highmore, S. Dak.; Arnautka (C. I. No. 4064) a selection from Arnautka (C. I. No. 1494) made at Akron, Colo.; Monad (C. I. No. 3320), a selection made from a field in Russia but tested at Dickinson, N. Dak.; Buford (C. I. No. 5295), a selection from Taganrog (C. I. No. 1570) made at Williston, N. Dak.; Kubanka No. 8 (C. I. No. 4063), a selection from Kubanka (C. I. No. 1440) made at Dickinson, N. Dak. Of these five, Acme and Monad are very rust resistant.

THE ARID BASIN AND COASTAL AREAS.

A study of the data from the six stations located in these western areas, as summarized in Table XXXIII, shows two facts definitely.

(1) Except for the Crimean group of winter wheats, the standard varieties of the western areas differ from those of the Great Plains and Prairie States.

(2) In these areas the better yields have been obtained from hard red winter wheats of the Crimean group or from some variety of soft white wheat.

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E. W. NELSON, Chief.

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FOOD HABITS OF THE SWALLOWS, A FAMILY OF VALUABLE NATIVE BIRDS.

By F. E. L. Beal, *Assistant Biologist.*[1]

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FOOD HABITS OF THE SWALLOWS

The swallows are the light cavalry of the army of birds, ever on the move, always on the skirmish line, their wings tireless. From early dawn until night they forage the fields of air, constantly on the alert to cut off stragglers from insect camps and missing no opportunity to destroy these enemies of the farmer. From time immemorial these birds have been the friends and companions of man. Whenever he has had a literature it has recorded the praise of the swallow. Ever since the human race has had a history "the swallow twittering from the straw-built shed" has roused the peasant at break of day to resume his labors, and he has returned to his cabin to rest "when the swallows homeward fly."

All the species are more or less gregarious and appear to like not only the companionship of their kind but also that of man, to whom many have attached themselves, not as parasites but as cheerful companions and helpful friends. Probably no group of birds has made such a change in nesting sites as have some species of swallows, which persistently use the structures of man as a shelter and foundation for their nests instead of those provided by nature.

[1] Prof. Beal, the most experienced economic ornithologist in the country, died on October 1, 1916, shortly after the preparation of this paper.—Editor.

Note.—This bulletin is a technical study of the food habits of the seven North American forms of the swallow family. It is for distribution in all sections of the United States.

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In their relations to man the swallows, as a group, are as harmless as any family in the bird kingdom, and yet they are more closely related to him socially than any other birds except domestic fowls. No complaint has ever been made that these birds harm either wild or cultivated fruit or seed or that they injure other birds. Although practically altogether insectivorous, they do not disturb domestic bees, and in a region where the silk-worm industry flourishes they would not harm the silkworms, for they do not eat Lepidoptera (caterpillars, moths, etc.) extensively, either larval or adult. The esteem in which swallows have always been held is well deserved. It is doubtful if there is a more useful family of birds in the world. Every provision should be made to induce them to stay about the farm or homestead.

Swallows are pronounced flycatchers in the sense that they catch their prey upon the wing. Their mouths are specially adapted to act as scoops and take in insects in the air. Probably no other family of land birds spends so many of the daylight hours upon the wing as the swallows. It would follow, therefore, that their food would be taken mostly in mid-air and that it would be limited to insects that fly or jump. This would eliminate from their dietary such forms as caterpillars and beetle larvæ and, in short, larvæ in general; also such creatures as millepeds, sowbugs, snails, and, to some extent, spiders, although these are able to fly under certain conditions by means of their webs.

That insects which spend most of their time in flight constitute the principal items of the swallow's food is verified by the examination of 2,030 stomachs. This shows that Hymenoptera (bees, wasps, and ants) and Diptera (flies) constitute more than 50 per cent of the average food of the seven North American species here treated (see tabular summary, p. 28). Hemiptera (bugs, cicades, tree hoppers, etc.) stand next in importance, although the species in general are not such good flyers and do not spend so much time on the wing as the Hymenoptera. The three insect orders, Hymenoptera, Hemiptera, and Diptera, constitute nearly 70 per cent of the average food of the swallows of the United States. Coleoptera (beetles) are less given to flying, and consequently are not so often taken, the small dung beetles (*Aphodius*) that fly over cow droppings in the evening being most commonly eaten. As all swallows apparently prefer to forage over the surface of still water, they take in their food such insects as aquatic Hemiptera and dragonflies, with other aquatic forms.

The swallow's habit of taking its prey upon the wing and its reluctance to alight upon the ground tend to exclude from its food all vegetable matter as well as nonflying insects. Stomach examination, while confirming this as a general rule, shows some exceptions. The

tree swallow, for instance, eats a notable quantity of vegetable food, and nearly all the species contrive to get a few caterpillars or other wingless prey, and take at least a taste of Orthoptera (grasshoppers, crickets, etc.).

There are within the limits of the United States 13 species of swallows, of which the following seven are of such wide distribution as to render their food habits a subject of economic interest: Purple martin (*Progne subis*); cliff, or eaves, swallow (*Petrochelidon lunifrons*); barn swallow (*Hirundo erythrogastra*); tree, or white-bellied, swallow (*Iridoprocne bicolor*); violet-green swallow (*Tachycineta thalassina*); bank swallow (*Riparia riparia*); and rough-winged swallow (*Stelgidopteryx serripennis*). The food of these seven species is discussed in the following pages.

PURPLE MARTIN.

Progne subis.

The purple martin (Pl. I, upper figure) occurs in nearly all parts of the United States where suitable nesting sites are found. As its nest is usually in a cranny of a building or in a house put up for its express use, it follows that the bird breeds chiefly in settled portions of the country. Probably at one time it nested in holes in cliffs, but that time is long past, and now, showing the greatest confidence in its human neighbors, the bird builds its nest as readily in the midst of a noisy city as about a country cottage or on a quiet farm.

For the determination of the food of the martin 205 stomachs were available, collected throughout the United States with a few from Canada. They represent the months from February to September, inclusive, and are fairly well distributed through that period. Examination shows that the food consists entirely of animal matter, insects with a few spiders and other allied creatures, with no trace of vegetable food. The largest item consists of Hymenoptera (23 per cent). These were found in 129 stomachs, of which 7 contained no other food. Ants (3.52 per cent) were found in 30 of these and formed the sole contents of 2. As many ants have no wings, they are probably snapped from the tops of weeds as the martin darts past. Occasionally, however, the bird had evidently met a swarm of winged ants and made nearly a full meal of them. Among the Hymenoptera were some useful parasitic species. Ants, on the contrary, are annoying if not harmful, so that while the bird's consumption of Hymenoptera is on the whole not a decidedly good function, it certainly results in little or no harm. Five stomachs contained remains of honey bees (*Apis mellifera*) with an aggregate of 11 individuals, all of them males, or drones.

Diptera, found in 50 stomachs and forming the sole contents of 7, stand next in the food of the martin. Eaten in every month in which stomachs were taken, they amount to 16.09 per cent of the food. They consisted largely of the long-legged tipulids, better known as daddy longlegs, whose larvæ are destructive to the roots of grass. Besides these, many of the Muscidæ, the family of the common house fly, were eaten, and a few specimens of robberflies (Asilidæ) were found. The latter are predacious insects and are said to be very destructive to bees.

Hemiptera, found in 70 stomachs, amount to 14.58 per cent of the food. They belong to several families, among the most abundant of which are the Pentatomidæ (stinkbugs), the Membracidæ (tree hoppers), and the Thyreocoridæ (negro bugs). The notorious squash bug (*Anasa tristis*) was found in 1 stomach. One stomach contained 26 specimens of *Nezara hilaris*, a pentatomid; others contained, respectively, 27, 25, 11, and 8 individuals of *Myodocha serripes;* and several others a less number. This shows how freely these bugs are eaten by the martin. *Leptoglossus oppositus* and *Metapodius femoratus*, large bugs that do much damage to plants and fruit, were found in two stomachs.

Coleoptera, the insects next in order of abundance, amount to 12.53 per cent of the food. Of these, 1.28 per cent were useful beetles, mostly Carabidæ, or ground beetles, with a few tiger beetles. The remainder belong to more or less harmful species. The Scarabæidæ, or May-beetle family (5.21 per cent), were found in 47 stomachs and are apparently the favorites. Many of them were small dung beetles (*Aphodius*), which hover over cow droppings in the early evening and so are easily captured by martins. One stomach contained 75 individuals of a single species, and another 35. Some of the larger flower beetles (*Euphoria*) also were taken, one form of which *E. inda*, often destructive to fruit, was found in 6 stomachs. One stomach contained 100 individuals of another small species of this family (*Strigoderma pygmæa*).

Among the most interesting beetles found in the stomachs were the Rhynchophora, or snout beetles. This group, commonly known as weevils, includes some of the most destructive species known. The cotton boll weevil (*Anthonomus grandis*) was found in two stomachs. The clover weevil (*Hypera punctata*) was found in nine stomachs, one of which contained 20, and others 17, 12, and 9 of these destructive insects. Insects of the genus *Balaninus*, which bore into and destroy nuts and large seeds, were found in 14 stomachs. The genus *Sitona* in several of its species is destructive to clover and allied plants; in one martin's stomach were found 53 individuals of the species *S. hispidula* and in another 16; in a third stomach were 27 specimens of *S. flavescens*, also a pest. The strawberry

PURPLE MARTIN (UPPER), BARN SWALLOW (MIDDLE), AND CLIFF SWALLOW (LOWER).

weevil (*Otiorhynchus ovatus*) occurred in one stomach. *Tomicus calligraphus*, one of the engraver beetles that work under the bark of trees, also was found in one stomach. In all, weevils of different species were found in 48 stomachs. Sundry other beetles, of more or less economic interest, made up 3.41 per cent of the food.

Lepidoptera usually appear in the stomachs of birds in the larval form—that is, as caterpillars—but as birds that take their prey upon the wing are not likely to capture caterpillars, this item of food with the swallows is usually composed of remains of adult insects. It amounts to 9.39 per cent of the food of the martin, and is mostly taken at the end of the season; that is, in August and September. None were taken in February and March, and for some unknown reason none were eaten in June. Small moths were found in 39 stomachs, and a butterfly (*Vanessa atalanta*) in 1. It is possible that there were more butterflies which could not be identified. Moths formed the sole contents of 11 stomachs, and in one 12 heads were counted. The distribution of this item of food through the season is very curious and not readily explainable. Over 93 per cent of it is eaten in August and September, with but little in any other month.

Orthoptera are eaten sparingly by the martin. Their total in the yearly food of the martin is only 1.09 per cent.

Dragonflies appear to be a favorite food of the martin. They were eaten every month except February and were contained in 65 stomachs, of which 7 held nothing else. Many were of the larger species, seemingly rather large morsels for the bird. The total for the season is 15.1 per cent of the food, a percentage unusually large for these insects and indicating that the martin hunts especially for them. The bank swallow is the only other species that eats enough dragonflies to warrant a separate record. Adult dragonflies live by killing other insects and thus are usually reckoned as useful creatures, but the young feed to some extent upon small fishes and do some harm in this way. Their destruction, therefore, may be regarded as having a neutral effect. Aquatic in their larval stage, dragonflies naturally stay about water or wet places, and as martins are likely to nest at a distance from water, to get them the birds must go to the haunts of the insects.

A few other insects, mostly Ephemeridæ, with a few spiders and sowbugs (8.09 per cent), complete the food. A bit of mollusk shell and a vertebra of a fish are among the curiosities noted.

Summary.—While in its food habits the martin does not inflict the direct injury upon man that the bird that preys upon his fruit does, yet it must be admitted that in its animal food in theory it does some harm. Among the Hymenoptera eaten are many parasitic species, all reckoned as useful insects, and the whole order are cer-

tainly useful in fertilizing flowers of plants. In many cases this function is essential, and without this intervention of insects many species of plants would become extinct. On the other hand, there is no evidence that plants suffer in any way from lack of insect service, and it is probable that in this one respect the balance in nature is nearly perfect and not likely to be disturbed by any increase of birds or corresponding decrease of insects. The martin may safely be protected and encouraged.

Following is a list of the insects identified in stomachs of purple martins and number of stomachs in which found:

ODONATA.	
Libellula sp	1
ORTHOPTERA.	
Tettix sp	5
HEMIPTERA.	
Cicada sp	3
Telamona sp	1
Platycotis sp	1
Micrutalis calva	1
Podisus subspinosus	1
Euschistus inflatus	1
Solubea pugnax	1
Nezara hilaris	1
Leptoglossus oppositus	2
Metapodius femoratus	1
Anasa tristis	1
Myodocha serripes	9
Gerris sp	2
LEPIDOPTERA.	
Vanessa atalanta	1
COLEOPTERA.	
Cicindela sp	1
Lebia sp	1
Anisodactylus baltimorensis	1
Rhantus bistriatus	1
Tropisternus sp	1
Cercyon ocellatus	1
Creophilus villosus	2
Philonthus sp	1
Hister abbreviatus	1
Hister cirilis	1
Glischrochilus fasciatus	9
Trogosita virescens	1
Buprestis lineata	1
Canthon sp	1
Onthophagus sp	1
COLEOPTERA—continued.	
Aphodius fimetarius	20
Aphodius inquinatus	19
Aphodius stercorosus	1
Aphodius sp	3
Dichelonycha sp	3
Strigoderma pygmæa	2
Euphoria inda	6
Criocephalus sp	1
Typophorus vittatus	1
Colaspis brunnea	2
Mylabris prosopis (Bruchus)	1
Serropalpus barbatus	1
Otiorhynchus ovatus	1
Sitona hispidula	3
Sitona flavescens	2
Sitona sp	4
Hypera punctata	9
Endalus æratus	1
Anthonomus grandis	2
Tylopterus pallidus	1
Balaninus nasicus	1
Balaninus sp	13
Sphenophorus pontederiæ	1
Sphenophorus callosus	1
Sphenophorus sp	1
Platypus flavicornis	2
Xyleborus impressus	1
Tomicus calligraphus	1
Chramesus icoriæ	1
HYMENOPTERA.	
Apis mellifera	5
Chrysis sp	1
Tiphia inornata	1
Scambus sp	1
Ichneumon irritator	1
Chalcis sp	1
Pogonomyrmex sp	1

CLIFF, OR EAVES, SWALLOW.

Petrochelidon lunifrons.

The cliff, or eaves, swallow (Pl. I, lower figure) is found locally throughout the United States. Its former and natural nesting site was under an overhanging bank of earth, as along a stream or under a cliff. Now the favorite spot for its nest is under the eaves of a building or occasionally under a roof if there is free

access to it, as in an open shed; for the eaves swallow does not like to go through a small hole to get to its nest as does the barn swallow. In the far West it may still be found nesting in the old-fashioned way, but where suitable buildings have been put up, this species has not been slow to avail itself of the safer and more sheltered site. Unfortunately, some people consider the nests of this swallow a disfigurement to the building on which they are placed. Were the nests attached to the front of a handsomely finished house, some complaint might justly be made, but smoothly finished and painted buildings are not what the bird requires. A roughly finished barn or other outbuilding or a brick structure to which the mud used in building will adhere, is more satisfactory and is usually chosen. Nests on an outside location are usually bottle-shaped and made of mud worked into pellets in the mouths of the builders. Probably these birds, like the swifts, are able to add to this mud some adhesive substance from their mouths which makes it adhere more firmly to the wall on which it is placed.

For the study of the food of the eaves swallow 375 stomachs were available, taken in every month from March to September and giving a fair representation of the food in each of these months, except March, in which only one stomach was taken. While the food consisted almost entirely of animal matter, a small portion (0.66 per cent) of vegetable matter was found in several stomachs, much of it being mere rubbish, but some recognizable as food material. As it has very little interest, either economic or academic, it may as well be disposed of forthwith. None was found in March or September, but scattering along through the other months were pieces of seeds and rubbish mostly taken accidentally with other food. Two stomachs, taken in May in Texas, were entirely filled with fruit of *Juniperus monosperma*, which was undoubtedly taken intentionally as food. This seems to show that the bird can at times subsist upon vegetable matter.

The animal food consists of insects, with a few spiders. Beetles are the largest item but one, and amount to 26.88 per cent. Of these 2.67 per cent are useful species, mostly ladybirds (Coccinellidæ), which are good fliers and so fall in the swallow's way. The predacious ground beetles, eaten by so many birds, do not form an important part of the swallow's food, as they are not generally much on the wing. Members of the May-beetle family (Scarabæidæ) amount to 4.97 per cent. They consist mostly of the small dung beetles (*Aphodius* and *Ataenius*) which are easily taken on the wing as they fly in swarms near the ground. A few of the larger species also were eaten, but most of them are too large for the swallow to manage.

The snout beetles, or weevils (Rhynchophora), are the most interesting insects eaten. They were taken nearly every month in fair quantities, but in September they constituted over 50 per cent of the food. This record, however, is probably due to the fact that special pains were taken during this month to collect birds in a locality specially infested by one species of weevil. In order to ascertain to what extent birds were preying upon the cotton boll weevil (*Anthonomus grandis*) 35 stomachs of the eaves swallow were collected in September in the vicinity of cotton fields in Texas. Every one of these stomachs contained boll weevils, and several contained other species also. Of the boll weevils 687 individuals were counted, an average of over 19 to each stomach, and it is probable that more were really present but being badly broken up could not be recognized. Let it be noted that these are not selected stomachs, but embrace every one of this species taken at that time and place. One of these contained 48 weevils, another 42, two contained 38 each, and three others 37, 35, and 33, respectively. Two stomachs taken at another time in Mississippi revealed 11 of these weevils. From the above facts it is evident that these birds were taking every one of these insects that came in their way and probably were making a special hunt for them.

The eaves swallow is particularly gregarious and lives in colonies that sometimes contain several hundred individuals. The writer has seen a colony of 80 nests, and larger ones have been observed. It is thus evident that such a colony in the near vicinity of an infested cotton field would have a very decided effect in restraining the increase of this pest. As the weevils are taken when in flight, it follows that migration to other fields would be largely prevented. Besides the boll weevils, 15 other species of snout beetles were eaten. All are harmful insects and liable at any time by some change in environment to become pests. The alfalfa weevil (*Phytonomus posticus*) was found in 11 stomachs taken in Utah. This is a recently imported pest and is doing much damage in the far West. Two species of weevils, *Sitona flavescens* and *Sphenophorus parvulus*, the one doing great damage to clover and the other feeding upon grass and grain, were found in several stomachs. The rice weevil (*Calandra oryza*), which does not confine its diet to rice, had been eaten by 5 birds.

Besides the weevils, a number of other beetles more or less harmful were eaten, 113 species being identified in the stomachs.

Hymenoptera exclusive of ants (8.24 per cent) amount to 20.51 per cent. Ants, mostly the winged forms, were eaten in every month except March. The month of greatest consumption (nearly 20 per cent) was September. Other Hymenoptera eaten are mostly wild bees and wasps, with some parasitic species. The remains of 35 honey

bees (*Apis mellifera*) were identified in 13 stomachs. More were probably present but unidentifiable. All were males, or drones. To what extent birds select their food has long been a matter of conjecture. When it is considered that the worker bees in the hive far outnumber the drones, it is evident that the foraging birds must meet many workers where they encounter a single drone. Evidently the drones are deliberately selected by the eaves swallow, for not a trace of a worker bee was found in any stomach.

Hemiptera in various forms in the food of this bird amount to 26.32 per cent. They belong to 11 families, chiefly the Capsidæ, Lygæidæ, Coreidæ, Pentatomidæ, and Jassidæ, which are probably the best flyers. While the great majority are harmful insects, the most interesting is the well-known chinch bug (*Blissus leucopterus*), which is said to cause a loss in the wheat crop of millions of dollars in years favorable to the insect's development. It was found in the stomachs of 6 eaves swallows, and 29 individuals were identified, but in one stomach, where only two entire specimens could be made out, the fragments of not less than 100 were plainly identified, and it is probable that the few here recorded are really the representatives of hundreds—perhaps thousands—that the birds had taken.

Diptera were eaten by the eaves swallow to the extent of 13.95 per cent. None were taken in March, but a fair percentage was recorded for each of the other months, the most being eaten in April (35.22 per cent). Few were identified further than as to family. Golden-green fleshflies were present in large numbers, together with many small soft midges not further identifiable. Craneflies, which are eaten by so many species of birds, were not found in the stomachs of these swallows.

Lepidoptera form an unimportant part of the cliff swallow's diet. Apparently but few birds are fond of adult butterflies or moths, though they may greatly relish their larvæ—caterpillars. While swallows seldom come in contact with caterpillars, one or two were identified, probably picked from the top of a weed or shrub as the bird sped past. A few moths made up the bulk of the lepidopterous food of the cliff swallow, 0.46 per cent for the year and 1.11 per cent for April; the month of maximum consumption.

Orthoptera, like moths and butterflies, are but lightly regarded by the cliff swallow. Of the year's food they constitute only 0.71 per cent, and in July, the month of greatest consumption, only 2.06 per cent. None were taken in March, April, or August, the last, with most insectivorous birds, the chief grasshopper month. The large size of many grasshoppers probably saves them from the swallows, for many are extensive fliers. Again, birds that eat grasshoppers usually take them to the ground, a branch of a tree, or the top of a fence, where they hammer them to fragments small enough

to be swallowed easily. This is manifestly impossible for the birds of this family, as their bills are weak and they do not perch on the ground or other places where they can beat their prey as do other birds.

A few other insects, as dragonflies, May flies, and lace-winged flies, several spiders, a snail, and a few bits of eggshell (collectively, 2.97 per cent) close the food account. That eggshells and snails should be taken by birds that so seldom alight upon the ground may seem a little curious, but as they come to the earth in order to get mud for their nests, they may possibly do so at other times. There were in the stomachs several gravel stones and one or two pieces of old mollusk shell, which, like the snail shell, must have been picked up from the ground.

Summary.—The food of the cliff swallow contains few elements that can be criticized from an economic point of view. The destruction of a few coccinellid beetles and some parasitic hymenopterans is theoretically harmful to the interests of man, but practically it has little effect. The bird does no direct injury, and it consumes many noxious insects, notably two of the most destructive pests that the country has ever known—the chinch bug and the boll weevil. In view of this record it is hoped that the practice of tearing down its nests will be discontinued. Cliff, or eaves, swallows should be protected and encouraged in every way. The belief that they harbor bedbugs in their nests is erroneous. Their parasites are of a different species from the one that afflicts mankind.

Following is a list of insects found in stomachs of cliff swallows and the number of stomachs in which found:

HEMIPTERA.	
Entylia concisa	1
Stictocephala festiva	2
Clastoptera obtusa	1
Agallia 4-punctata	1
Deltocephalus sp	1
Eucanthus sp	1
Homalodisca sp	1
Hymenarcys nervosa	1
Nezara hilaris	1
Emesa sp	1
Sinea diadema	1
Sinea sp	1
Reduviolus sp	1
Blissus leucopterus	6
Perigenes sp	2
Salda sp	1
ORTHOPTERA.	
Tettix sp	2
Ceuthophilus sp	1
COLEOPTERA.	
Elaphrus ruscarius	4
Elaphrus sp	1
Dyschirius marinus	1
COLEOPTERA—continued.	
Pterostichus lucublandus	1
Pterostichus scitulus	1
Pterostichus sp	1
Amara fallax	1
Amara sp	2
Agonoderus pallipes	1
Selenophorus sp	1
Anisodactylus baltimorensis	2
Brychius sp	1
Cnemidotus callosus	1
Cœlambus patruelis	1
Helophorus lineatus	21
Helophorus sp	1
Octhebius puncticollis	1
Tropisternus limbalis	1
Laccobius agilis	2
Laccobius ellipticus	1
Philhydrus hamiltoni	1
Cercyon prætextatum	1
Cercyon sp	1
Megasternum sp	1
Cryptopleurum minutum	4
Heterocerus sp	2
Philonthus varians	1
Philonthus lomatus	1

COLEOPTERA—continued.	
Philonthus sp	1
Tachyporus californicus	1
Megilla maculata	14
Hippodamia ambigua	3
Hippodamia 15-maculata	1
Hippodamia convergens	16
Hippodamia 13-punctata	3
Hippodamia parenthesis	1
Hippodamia sp	1
Coccinella sanguinea	2
Coccinella californica	2
Hyperaspis fimbriata	1
Scymnus collaris	2
Scymnus partibus	1
Scymnus loewii	3
Scymnus marginicollis	1
Scymnus sp	3
Typhœa fumata	1
Dermestes mannerheimii	1
Hister sellatus	1
Hister interruptus	1
Hister abbreviatus	1
Hister curtatus	1
Hister americanus	2
Hister subrotundus	4
Saprinus insertus	1
Pachylophus æneipunctatus	2
Cercus sericans	1
Glischrochilus fasciatus	12
Melanophthalmus gibbosus	1
Limnichus punctatus	2
Dryops striata	1
Chauliognathus marginatus	36
Chauliognathus sp	1
Onthophagus tuberculifrons	1
Onthophagus pennsylvanicus	2
Onthophagus sp	6
Atœnius sp	1
Aphodius fimetarius	61
Aphodius granarius	3
Aphodius vittatus	5
Aphodius lividus	1
Aphodius inquinatus	16
Aphodius sp	40
Strigoderma pygmœa	3
Callidium antennatum	1
Hæmonia nigricornis	7
Lema trilineata	2
Chlamys sp	1
Diachus auratus	3
Myochrous denticollis	6
Typophorus viridicyaneus	1
Typophorus sellatus	7
Colaspis sp	1

COLEOPTERA—continued.	
Plagiodera prasinella	1
Gastroidea polygoni	1
Gastroidea viridula	1
Gastroidea cyanea var. *cæsia*	2
Lina scripta	11
Cerotoma trifurcata	2
Diabrotica 12-punctata	4
Diabrotica soror	5
Diabrotica sp	1
Epitrix parvula	2
Epitrix sp	1
Longitarsus melanurus	2
Gliptina atriventris	2
Chætocnema pulicaria	5
Psylliodes punctulata	1
Mylabris amicus (*Bruchus*)	2
Notoxus sp	4
Anthicus sp	1
Sitona flavescens	2
Sitona sp	12
Apion vespertinum	1
Apion cavifrons	1
Apion sp	1
Phytonomus posticus	13
Anthonomus grandis	37
Anthonomus eugenii	1
Rhinoncus pyrrhopus	2
Baris confinis	1
Balaninus sp	15
Sphenophorus placidus	1
Sphenophorus parvulus	1
Sphenophorus sp	1
Calandra oryza	5
Platypus flavicornis	1
Tomicus pini	1
Hylastes sp	1
Brachytarsus variegatus	1
DIPTERA.	
Lucilia sp	2
Fannia canicularis	1
HYMENOPTERA.	
Apis mellifera	13
Tiphia sp	1
Formica sp	1
Ponera coarctata pennsylvanica	2
Tapinoma sessile	1
Lasius alienus	1
Lasius sp	5
Ichneumon sp	1
Urosigalphus sp	1
Apanteles sp	1

BARN SWALLOW.

Hirundo erythrogastra.

The barn swallow (Pl. I. middle figure) occurs in nearly the whole country where suitable buildings for its occupancy can be found, but on the Pacific side of the continent it still largely frequents its original nesting sites in caves and holes in cliffs. That it is ready at

any time to give up the old-fashioned homestead for one provided by man is shown, however, in all well-settled localities of the far West. There it avails itself of barns, sheds, and bridges, as it has long done in the East, where its right to a nesting place among the rafters is so well established that when new barns are built a hole is frequently made up near the peak of the gable for the birds to pass easily in and out.

The food of the barn swallow, like that of its allies, consists almost wholly of insects, with an occasional spider or snail. A few bits of vegetable matter are taken accidentally—that is, snatched from the top of a weed or shrub with an insect taken as the bird dashes past. Occasionally a berry or seed is eaten intentionally. Ordinarily all food is taken on the wing, but snails have been picked up, probably when the bird was getting mud for its nest.

For the investigation of the food of this swallow 467 stomachs were available, collected in the months from March to October, in 27 States, the District of Columbia, and Canada. The first analysis shows that the food is made up of 99.82 per cent animal matter to 0.18 vegetable. The latter is considerably less than that eaten by the cliff swallow. All the vegetable matter found was contained in six stomachs, but it was real food in only four. One of these revealed seeds of the elderberry (*Sambucus*) and of *Cornus sericea*. Vegetable food in this stomach made up 75 per cent of the contents. The second stomach held a single kernel of buckwheat, the third a root or bulb, and the fourth two seeds of *Croton texensis*. Having taken so little vegetable food, it seems curious that the bird should have eaten any at all.

Of the animal food beetles of various families amount to 15.63 per cent. Useful species, that is, those that prey upon other insects, as the predacious ground beetles (Carabidæ) and the ladybirds (Coccinellidæ), amount to 3.4 per cent. The May-beetle family (Scarabæidæ), apparently the most palatable, are eaten to the extent of 6.2 per cent. These are mostly small dung beetles of various species of the genus *Aphodius*. One stomach was noted as containing 50 or more, and another, several hundred. Snout beetles, or weevils (1.96 per cent) include a variety of species. First in interest is the cotton boll weevil (*Anthonomus grandis*), found in 12 stomachs, with an average of somewhat more than 6 individuals each. Next in interest is the rice weevil (*Calandra oryza*), which was identified in 8 stomachs, with 153 individuals in one, 50 in another, and from 15 to 20 in a third. Two species of the genus *Sitona* were found, *S. flavescens* and *S. hispidula*, both very destructive to forage crops. Among other weevils were two of the destructive engraver beetles that do so much damage to timber. In all, about 80 species of beetles

were identified in the stomachs, most of them harmful and some exceedingly so.

Ants are eaten by the barn swallow to the extent of 9.89 per cent of the food, some stomachs being entirely filled with wingless species. These were found in 124 stomachs, and in 14 there was no other food. Most of them were of rather large size as compared with those taken by the flicker and other ground-feeding birds. One stomach, however, contained approximately 1,000 small individuals. Another contained between 300 and 400 of the ant *Solenopsis molesta*, a small species. Hymenoptera other than ants (12.82 per cent) were found in 254 stomachs and are evidently a favorite food of this swallow. Besides the common bees and wasps were many parasitic forms. One male, or drone, honey bee was found.

Hemiptera formed 15.1 per cent and from the regularity with which they occur in the food are evidently very palatable. They were found in 192 stomachs, and 16 families were identified. Of these the most important are the Pentatomidæ, or stinkbugs; Jassidæ, or leaf hoppers, of which one stomach was estimated to contain at least 1,000; Capsidæ, or leaf bugs, contained in 48 stomachs; Aphididæ, or plant lice; and Lygæidæ, which are represented by the notorious chinch bug (*Blissus leucopterus*), found in 7 stomachs. This last pest is too well known to require comment. It is well to know its enemies.

Diptera are evidently the choice food of the barn swallow. They average 39.49 per cent of the food, or more than twice that of any other order of insect, and nearly two-fifths of the whole. They were contained in 338 stomachs, or nearly three-fourths of all, and 33 contained no other food. In March they constitute 82 per cent of the food, and in September, the month of least consumption, nearly 18 per cent. These insects are mostly allied to the common house fly, and were identified in 110 stomachs, but several other families are represented. Among them are the long-legged craneflies (Tipulidæ), a number of horseflies (Tabanidæ), and several robberflies (Asilidæ), which prey upon other insects and are said to be very destructive to honey bees. The consumption of flies by the barn swallow is, to say the least, interesting. It is greater than that of any of the flycatchers (Tyrannidæ) except one and is exceeded by only two other species of swallows. Only such birds as are very active on the wing can catch many flies. Thrushes and blackbirds get a few, but as a rule these are only the craneflies, which move sluggishly and breed in colonies where birds can easily reach them.

Lepidoptera are evidently not greatly relished by the barn swallow. The adult insects can hardly be considered a favorite food for any species of bird, as most of the lepidopterous food is eaten in the larval

state. Swallows can not easily avail themselves of this food, for caterpillars are not readily taken on the wing. All but one of the lepidopterans eaten by the barn swallow were taken in the adult state and amount to only 2.39 per cent of the food. Nearly all were secured in October, and in no other month did they form as much as 1 per cent.

Grasshoppers and crickets are a favorite food for many insectivorous birds and in many instances are evidently carefully sought after, but they form only 0.51 per cent of the food of this swallow. Grasshoppers are frequently upon the wing and will rise in front of one walking through grassy fields and often fly several rods. While not a general rule, some species are capable of making long-sustained flights. Flycatchers probably capture them in mid-air, and swallows might take them in the same way if they cared for them. The greatest consumption by this swallow (2.54 per cent) occurs in August.

Other insects of more or less importance serve to a certain extent as food for the barn swallow. These are dragonflies (4 per cent), found in 26 stomachs, May flies (Ephemerida) found in 13, spiders in 9, and snails in 9. Dragonflies, though large and conspicuous insects, are not taken by many birds, as they are very agile, but flycatchers and swallows seem to capture them easily.

Summary.—There seems to be little reason for criticizing the food of the barn swallow, as the bird eats neither fruit nor grain and does not injure the farmer's crops in any way. It feeds upon many injurious insects and destroys some of the worst of the farmer's pests. It is cheerful and companionable and a pleasant adjunct to rural life.

Following is a list of insects identified in stomachs of barn swallows and the number of stomachs in which found:

ORTHOPTERA.	
Conocephalus sp	2
HEMIPTERA.	
Cercsa bubalis	1
Entylia sinuata	1
Stictocephala lutea	1
Campylenchia curvata	1
Ophiderma sp	1
Thyreocoris pulicaria	1
Amnestus pusillus	1
Geotomus sp	1
Pangæus sp	1
Blissus leucopterus	7
Myodocha serripes	3
Sinea diadema	1
COLEOPTERA.	
Elaphrus ruscarius	1
Bembidium variegatum	1
Amara sp	2
Cnemidotus 12-punctatus	1
Cnemidotus sp	1
Helophorus lineatus	1
COLEOPTERA—continued.	
Sphæridium scarabæoides	1
Cryptopleurum minutum	4
Heterocerus tristis	1
Atheta sp	1
Philonthus hepaticus	1
Philonthus siegwaldi	1
Philonthus sp	1
Boletobius sp	1
Olophrum obtectum	1
Phalacrus penicillatus	1
Hippodamia convergens	2
Scymnus loewii	1
Scymnus sp	1
Aulonium sp	1
Dermestes fasciata	1
Dermestes sp	1
Hister abbreviatus	2
Hister bimaculatus	2
Hister americanus	2
Hister subrotundus	2
Dendrophilus punctulatus	1
Saprinus pennsylvanicus	2
Saprinus assimilis	2

COLEOPTERA—continued.

Saprinus æneicollis	2
Saprinus lubricus	1
Saprinus fimbriatus	1
Saprinus sphæroides	1
Carpophilus dimidiatus	1
Stelidota geminata	1
Glischrochilus fasciatus	10
Dryops striata	1
Cryptohypnus obliquatus	1
Agrilus sp	2
Onthophagus hecate	9
Onthophagus tuberculifrons	2
Onthophagus pennsylvanicus	32
Onthophagus sp	19
Atœnius cognatus	1
Aphodius fimetarius	43
Aphodius vittatus	3
Aphodius inquinatus	22
Aphodius prodromus	1
Aphodius sp	39
Dichelonycha sp	1
Strigoderma pygmæa	2
Hæmonia nigricornis	13
Cryptocephalus trivittatus	1
Cryptocephalus sp	2
Cerotoma trifurcata	3
Diabrotica scror	1
Haltica obliterata	1
Crepidodera helxenes	2
Crepidodera sp	1
Epitrix cucumeris	1
Epitrix parvula	1
Chætocnema pulicaria	1
Odontota dorsalis	1
Mylabris prosopis (Bruchus)	1
Notoxus alamedæ	2
Notoxus sp	3
Anthicus sp	1
Sitona hispidula	5
Sitona flavescens	2

COLEOPTERA—continued.

Sitona sp	8
Anthonomus grandis	12
Gymnetron teter	1
Baris sp	1
Trepobaris elongatus	1
Trichobaris texana	1
Centrinus picumnus	2
Limnobaris deplanata	1
Balaninus parvidens	1
Balaninus sp	4
Sphenophorus parvulus	1
Sphenophorus placidus	1
Sphenophorus sp	1
Calandra oryza	8
Tomicus cacographus	1
Tomicus pini	7
Hylastes sp	10
Brachytarsus variegatus	1

DIPTERA.

Chrysops sp	3
Parephydra humilis	1
Lucilia cæsar	2
Lucilia sp	3
Calliphora vomitoria	8
Stomoxys calcitrans	1

HYMENOPTERA.

Apis mellifera	1
Tiphia inornata	2
Tiphia sp	1
Solenopsis molesta	1
Myrmica scabrinodis	1
Aphenogaster fulva	3
Lasius sp	1
Formica fusca var. *neoclara*	1
Colpognathus sp	1
Ophion sp	4
Spilochalcis flavipes	1
Chalcis sp	1

TREE, OR WHITE-BELLIED, SWALLOW.

Iridoprocne bicolor.

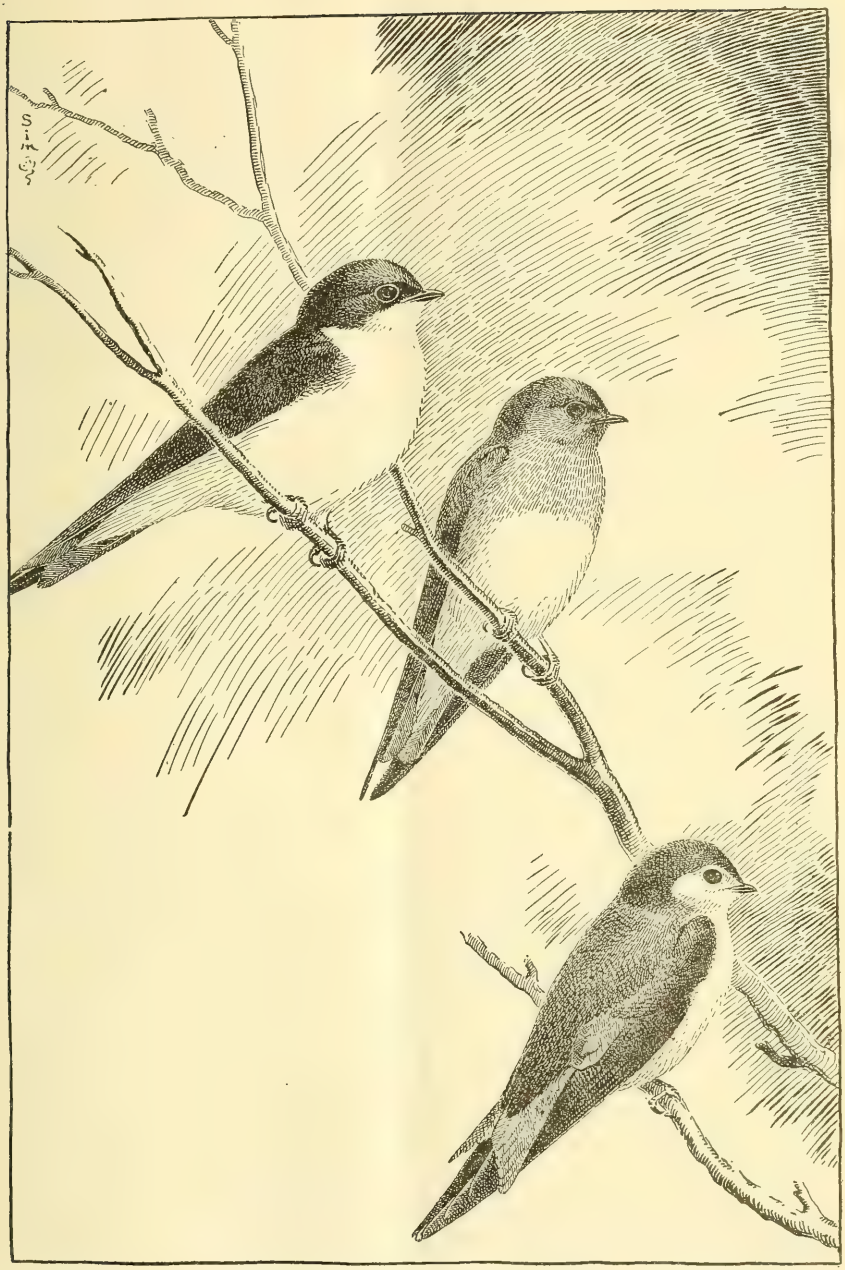
The tree, or white-bellied, swallow (Pl. II, upper figure), as it is variously called, is found all over the United States except in some desert or extensive treeless areas. In a state of nature this bird builds its nests in hollow branches or dead trunks of trees, and to-day may occasionally be seen occupying one of its original haunts. Boxes put up for wrens and bluebirds seem to suit the tree swallow exactly, and when available these are taken in preference to the hollow branch.

In its food habits this species differs somewhat from other American swallows in that it eats an appreciable quantity of vegetable food, frequently filling its stomach completely with berries or seeds. To determine the extent of this difference, 343 stomachs were examined, collected in every month of the year in 22 States, British

Columbia, Ontario, and New Brunswick, and fairly well representing the region from Maine to California and from Canada to Florida. Of these 80 contained vegetable food and 35 contained nothing else. In the first analysis the food divided into 80.54 per cent animal matter to 19.46 per cent vegetable.

The vegetable food is made up of a few varieties of seeds and berries, but more than nine-tenths of it consists of the fruit of a single shrub, the bayberry, or waxberry (*Myrica carolinensis*). The fruit of this plant consists of small, dry, hard seeds overlaid with a covering of small, irregular black granules, like old-fashioned gunpowder, over which is spread a coating of white wax, probably the nutritious part of the fruit. This was found in 70 stomachs, 30 of which contained no other food. The berries, as well as the whole plant, are highly aromatic and are eaten by many species of birds, but not by any so exclusively as by the tree swallow. They comprise 16.9 per cent of the food; and as they are eaten all the summer, a time when insects are abundant, it is evident that they form a standard article of diet and are not a makeshift for lack of better food. Of other fruits red-cedar berries (*Juniperus virginiana*) were found in 3 stomachs, rough-leaved cornel (*Cornus asperifolia*) in 4, and Virginia creeper (*Parthenocissus quinquefolia*) in 1. Seeds (2.56 per cent) complete the vegetable food, a grass seed (*Zizaniopsis miliacea*), one of the smartweeds (*Persicaria persicaria*), and an unknown seed each being found in a single stomach.

Beetles collectively total 14.39 per cent, of which the useful species amount to 0.97 per cent. Scarabæidæ, the favorites, were eaten to the extent of 5.86 per cent. They were mostly of the genus *Aphodius*, small dung beetles, which, much given to flying about early in the evening, are easily captured by the swallows. They were found in 76 stomachs, one of which contained nearly 100. Weevils, or snout beetles, were eaten to the extent of only 1.9 per cent. The species selected, however, are important. Cotton boll weevils (*Anthonomus grandis*), 45 in number, were found in 6 stomachs; *Hypera punctata*, the clover weevil, was found in 1 stomach; *Sitona hispidula*, a weevil that does great damage at times, in 10; and *S. flavescens*, another destructive species, in 2 stomachs. Others of the genus *Sitona*, not specifically identified, were found in 30 stomachs. *Tomicus pini*, an engraver beetle most destructive to pine trees, was found in 11 stomachs. Altogether weevils were found in 61 stomachs, one of which contained 68 individuals, another 40, and a third 30. Among other beetles are several forms commonly known as flea beetles. One of these, *Epitrix cucumeris*, very destructive to cucumbers, potatoes, and other vegetables, was found in 19 stomachs. Other species of similar habits, found in stomachs of tree swallows, are *Haltica foliacea* and *Phyllotreta sinuata*. In all, 43 species of



TREE SWALLOW (UPPER), ROUGH-WINGED SWALLOW (MIDDLE), AND VIOLET-GREEN SWALLOW (LOWER).

beetles were identified, of which the majority are injurious to plant life in some form.

Ants (6.37 per cent), many of which are winged forms, seem to be well relished by tree swallows. Most of them are eaten from May to October. February is the month of maximum consumption (25 per cent); but as only 4 stomachs were taken in this month, the record can not be considered representative. The great bulk of this food was taken from May to October. Hymenoptera other than ants (7.58 per cent) were taken in every month but two, March and December; and as but few stomachs were secured in these months, the omission is probably accidental. This item of food is made up of wild bees and wasps, with a large proportion of parasitic species. No domestic bees were observed.

Hemiptera, the order including widely different insects, from the little plant louse (aphid) to the large harvest fly (cicada), do not appear repugnant to birds because of their odor; in fact, the family Pentatomidæ, generally known as stinkbugs, forms a staple article of diet of most insectivorous birds. They were found in 5 stomachs of the tree swallow. Tree hoppers (Membracidæ) were found in 6 stomachs, leaf hoppers (Jassidæ) in 9, and plant lice (Aphididæ) in 11. Probably more of the last were present, but these fragile creatures are so easily reduced to a pulp that the action of the stomach soon renders them unrecognizable. The most interesting family of the Hemiptera in this connection are the Lygæidæ, found in only 3 stomachs, but in one represented by the remains of 80 chinch bugs (*Blissus leucopterus*). The bird had evidently encountered a swarm of these insects in flight and had filled up on them, an indication that they are palatable and will be taken whenever found.

Diptera form the largest item of the tree swallow's food (40.54 per cent). They were eaten all through the year, but mostly in the colder months. The greatest quantity (89.5 per cent) was taken in November and the least (6.98 per cent) in August, which is proverbially the month of flies. While numerous, they represent but few families, and only 5 were identified in the stomachs: Craneflies (Tipulidæ), horseflies (Tabanidæ), robberflies (Asilidæ), flower flies (Syrphidæ), and house flies (Muscidæ), the last of which were by far the most numerous. The syrphus flies, found in 10 stomachs, are usually considered useful insects, as many when in the larval state feed upon plant lice and others act as scavengers.

Lepidoptera were eaten only in the months from April to September, the greatest quantity in August (5.02 per cent). They were found in 20 stomachs, 15 of which contained the adult moths and 5 the larvæ, or caterpillars; an indication that the bird takes the adult insect probably because of its method of feeding—upon the wing. The average for the year is only 1.07 per cent.

Grasshoppers, found in 13 stomachs collected in the two months August and September, amount to a little more than 2 per cent in each, an average of only 0.37 per cent for the year. This indicates that the tree swallow does not seek grasshoppers, for 112 stomachs were taken in August (the grasshopper month), and even a moderate appetite for these insects would have been revealed by that number of stomachs.

Among various other orders represented in the tree swallow's food, remains of dragonflies (Odonata) were found in 25 stomachs, one of which contained fragments of 10 individuals. It has been suggested that grasshoppers are too large to be managed by such small birds as swallows, but a bird that can successfully dispose of dragonflies should have little trouble with grasshoppers. Both of these insects have harsh, crisp wings and stiff legs, while the body wall is hard and not easily crushed. Both have hard, stout jaws, which, remaining in the bird's stomach, serve to show what kind of food has been eaten. May flies (Ephemerida) were found in 11 stomachs.

Spiders (Arachnida) were found in 3 stomachs. In one a swarm of minute young ones, evidently newly hatched, constituted 99 per cent of the food. This may indicate that spiders are not distasteful, but hard to get. In one stomach was found a small piece of fishbone, an unaccountable item in the food of the tree swallow. These various items together amount to 4.64 per cent and close the food account.

Summary.—In the food of the tree, or white-bellied, swallow one point is prominent—in its vegetable food it has no relation to man. Every item is wild and of no use. In its insect diet it destroys some parasitic Hymenoptera, some carnivorous Diptera, and a few other useful insects, but this fault it has in common with most other insectivorous birds, and in common with them it is engaged in reducing the great flood of insect life to a lower level. Let it be protected and encouraged.

Following is a list of the insects identified in stomachs of tree swallows and the number of stomachs in which found:

ODONATA.	
Lestes sp	8
ORTHOPTERA.	
Tettix sp	1
HEMIPTERA.	
Stictocephalus sp	1
Blissus leucopterus	1
Pamera sp	1
Limnotrechus sp	1
COLEOPTERA.	
Clivina sp	1
Pterostichus sp	1
Amara sp	3
COLEOPTERA—continued.	
Platynus variolatus	3
Casnonia pennsylvanica	1
Agonoderus californicus	1
Discoderus robustus	1
Cnemidotus 12-punctatus	1
Bidessus affinis	1
Hydroporus sp	1
Berosus striatus	1
Helophorus lacustris	1
Helophorus sp	1
Hydrobius mathewsii	1
Sphæridium scarabæoides	5
Cercyon sp	1
Cryptopleurum minutum	1
Aleochara bimaculata	1

COLEOPTERA—continued.

Philonthus sp	3
Stenus sp	1
Trogophlœus sp	1
Hister subrotundus	2
Hister sp	1
Saprinus pennsylvanicus	1
Conotelus sp	2
Stelidota sp	4
Omosita colon	3
Glischrochilus fasciatus	3
Monotoma picipes	1
Heterocerus undatus	1
Heterocerus sp	1
Drasterius elegans	2
Chauliognathus marginatus	1
Onthophagus hecate	1
Onthophagus pennsylvanicus	3
Onthophagus sp	4
Aphodius fimetarius	33
Aphodius ruricola	1
Aphodius vittatus	1
Aphodius inquinatus	27
Aphodius sp	14
Dichelonycha sp	2
Anomala varians	2
Strigoderma pygmœa	11
Hœmonia nigricornis	27
Exema conspersa	1
Diabrotica sp	1
Cryptocephalus venustus	1
Pachybrachys sp	1
Diachus auratus	1
Colaspis sp	1

COLEOPTERA—continued.

Cerotoma trifurcata	4
Haltica foliacea	1
Epitrix cucumeris	19
Phyllotreta sinuata	1
Notoxus alamedæ	1
Notoxus sp	2
Anthicus sp	5
Sitona hispidula	12
Sitona flavescens	2
Sitona sp	31
Apion porcatus	2
Hypera punctata	1
Phytonomus sp	1
Anthonomus grandis	6
Orchestes vittata	1
Centrinus sp	1
Tychius sp	1
Hylastes sp	1
Rhinoncus pyrrhopus	1
Balaninus sp	12
Tomicus pini	11
Tomicus sp	2

DIPTERA.

Eristalis tenax	1
Syrphus sp	10

HYMENOPTERA.

Augochlora pura	1
Halictus sp	1
Lasius sp	1
Tiphia sp	2
Ophion sp	1

VIOLET-GREEN SWALLOW.

Tachycineta thalassina.

The violet-green swallow (Pl. II, lower figure) is found only on the Pacific side of the continent from the eastern slope of the Rockies to the coast. It extends as far north as Alaska in the summer, but in winter retires south beyond our borders. Its original nesting place was a hollow branch or tree trunk, but holes in cliffs and abandoned woodpecker nests also were used. The big oaks of California almost always furnish sites of this kind in exposed hollows of older branches that have died and broken off. This species has not as yet abandoned its natural nesting site for one of man's construction, although it does not avoid human society and has been known to build in a nook in a building. Also, on sunny afternoons late in summer, when the young have left the nest, hundreds of them may be seen sitting in long rows on telegraph wires preening their feathers and twittering with an air of perfect comfort.

For a study of the food of this swallow 110 stomachs were available, collected in Arizona, California, Oregon, Colorado, Wyoming, and Alaska, and in all the months from March to September. The violet-green swallow is strictly insectivorous, but bits of vegetable

matter were found in two stomachs; in one a bit of a kernel of oats, in the other a single seed of carrot. Both stomachs were taken in California in August. At that time certain species of ants may be seen harvesting the seeds of grass and other plants. It may be that a swallow picked up an ant carrying a seed and so got a bit of vegetable food, especially as these birds eat a great many ants. In any case the vegetable matter must be recorded as a mere trace, and the whole food rated as practically 100 per cent animal matter.

Beetles constitute 10.57 per cent of the food, 1.46 per cent being of useful species. The others were more or less harmful, but none have attracted attention by their depredations, although several have at times done much damage in isolated cases. In all, 24 species were identified, but none of them are familiar. The violet-green swallow has not yet come sufficiently in contact with agriculture to feed much upon the insects that destroy the farmers' crops.

Ants (9.42 per cent) were eaten from May to September. Most of them were taken in the first three months, nearly two-thirds of them in July. All of a series of six stomachs collected at Sunol, Cal., in July were completely filled with ants. Wasps and bees (17.48 per cent) are eaten in every month of the season except April. A number of parasitic species were observed, as well as a few gallflies (Cynipidæ), but no honey bees.

Hemiptera constitute the largest item of food (35.96 per cent). They are eaten in every month of the bird's stay in the North, the fewest in March, the most in September (68.36 per cent). They were selected from 12 different families, of which the Jassidæ, or leaf hoppers, were the favorites, having been found in 25 stomachs. The Capsidæ, or leaf bugs, were found in 23 stomachs, the other families in a less number. No other species of swallow has eaten so large a percentage of Hemiptera, and the value of this work can hardly be overestimated. Of the 12 families of bugs eaten by the violet-green swallow, all but 1 are plant eaters, and some, like the Jassidæ, do a great deal of damage every year; those like the Psyllidæ, the Membracidæ, and the Aphididæ are small insects but wonderfully prolific and do an immense amount of mischief without attracting attention until the harm is done. Birds that destroy these creatures are certainly doing good work.

Diptera are apparently a favorite food of the violet-green, as of other swallows. They are eaten in every month of the season, especially in the spring months, when they constitute nearly half the food. From May they gradually dwindle to less than 2 per cent in September. The total for the season is 19.36 per cent. The great mass of it was of such soft-bodied insects that in many cases it was impossible to make identifications more definitely than as to order. Craneflies (Tipulidæ) were identified in two stomachs.

No Orthoptera were found in this investigation of the food of the violet-green swallows.

Lepidoptera are eaten by this swallow to a small extent (3.12 per cent). They were taken in five months, but in only three of these do they attain even a fair percentage. Remains of small moths were found in seven stomachs and caterpillars in three.

A small mass (4.09 per cent), mostly of unidentifiable matter, was found in three or four stomachs. In two it was made out to be composed partly of Ephemeridæ, which are easily crushed.

Summary.—Little can be said of the food of the violet-green swallow. The mischief that birds do is usually through the vegetable portion of their diet. With this bird that element is eliminated at once. Whatever harm it does must be through the insects it eats. Of these the parasitic Hymenoptera are probably the most important, and only less so are the few predatory beetles and bugs it destroys. On the other hand it devours an immense number of harmful and annoying insects.

Following is a list of insects identified in stomachs of violet-green swallows, and the number of stomachs in which found:

HEMIPTERA.	
Idiocerus duzei	1
Reduviolus sp	1
Peritrechus fraternus	1
COLEOPTERA.	
Elaphrus ruscarius	1
Agonoderus pallipes	2
Bradycellus ruprestis	1
Laccobius agilis	1
Hydrobius fuscipes	1
Aleochara bimaculata	1
Aleochara sp	1
Oxypoda sp	1
Philonthus sp	1
Platystethus americanus	1
Agrilus sp	1
COLEOPTERA—continued.	
Aphodius granarius	1
Aphodius vittatus	7
Aphodius sp	3
Asemum sp	1
Hæmonia nigricornis	1
Diachus auratus	1
Haltica sp	1
Epitrix parvula	3
Epitrix sp	1
Notoxus sp	3
Anthicus punctulatus	1
Anthicus sp	1
Cantharis sp	1
Balaninus sp	1
Dendroctonus englemanni	3

BANK SWALLOW.

Riparia riparia.

The bank swallow inhabits practically the whole world, and in the United States it is more or less local, depending in the breeding season much on suitable places for nesting burrows. The nests are made by boring a nearly horizontal hole in the face of a bank of earth. In a state of nature suitable bluffs occur for the most part along the banks of streams, and it is probable that even now nine-tenths of the bank swallows in the country nest along watercourses. This species still adheres to its primitive nesting habits and does not use the structures of man, except to occupy the banks of earth exposed by his engineering operations.

The following discussion of the food of the bank swallow is based upon examination of 394 stomachs collected in the months from April to September from 21 States, the District of Columbia, and Canada. The food consisted practically of animal matter alone, but 3 small seeds were found in as many stomachs, probably taken accidentally, and these in the final analysis amounted to only 0.02 per cent of the total. The real food is made up of various insects and a few spiders.

Of insects, Coleoptera amount to 17.9 per cent, and of these 0.66 are useful species; that is, predacious ground beetles (Carabidæ) and a few ladybirds (Coccinellidæ), which devour plant lice. May beetles (Scarabæidæ) amount to 5.48 per cent. These were mostly tumblebugs or the smaller dung beetles, which, while they do no marked harm, do no special good. Fifty individuals of one species (*Aphodius inquinatus*) were found in one stomach. Snout beetles, or weevils (Rhyncophora), were eaten by the bank swallow to the extent of 5.78 per cent of its food. They occurred in 91 stomachs, in one of which 48 individuals were found, and nearly as many in several others. The rice weevil (*Calandra oryza*), so destructive to all kinds of stored grain, was found in 9 stomachs, one of which contained 40 individuals, two others 20 each, and others a less number. Cotton boll weevils (*Anthonomus grandis*), 80 in number, were found in 11 stomachs. One stomach taken in Utah contained two alfalfa weevils (*Phytonomus posticus*), insects which have done great damage in that region. One individual of the plum curculio (*Conotrachelus nenuphar*) was found in a stomach taken in New York. The genus *Sitona* contains a number of very harmful species, many of which were found in 45 stomachs. One stomach contained 26 individuals. Other beetles of a more or less harmful character amount to 5.98 per cent. Among them are several species of the well-known flea beetles, so injurious to garden truck. One of these, *Epitrix cucumeris*, was found in 10 stomachs.

Ants, most of which were winged forms, were eaten by the bank swallow to the extent of 13.39 per cent of their food. None were taken in April, but in the other months they form a large percentage of the diet. They appear to be a favorite food, having been found in 121 stomachs and forming the total contents of 11. Other Hymenoptera were found in 207 stomachs, and 6 contained no other food. As with all birds that capture their prey on the wing, the swallows take many useful parasitic Hymenoptera with the others. No honey bees were identified.

The bank swallow does not exhibit that fondness for Hemiptera shown by several other members of the swallow family. These insects aggregate for the year only 7.96 per cent, the least eaten by any of the family except the tree swallow. They were taken in every month of the season, but in rather moderate quantities, the most

in August (17.69 per cent). Leaf hoppers (Jassidæ), plant lice (Aphididæ), and tree hoppers (Membracidæ) were found in 22, 13, and 10 stomachs, respectively. These are all small insects, but they often do an immense amount of harm. Six other families of Hemiptera were identified in the stomachs, but in less quantities than the above. No special pest was discovered, but nearly all terrestrial Hemiptera are harmful.

Diptera constitute the largest element of the food of 4 of the 7 species herein discussed. With the bank swallow they form 26.63 per cent of the diet. Most of them belong to the family of the housefly (Muscidæ) and the family of the craneflies (Tipulidæ). The last are slow-flying creatures and can be easily captured by swallows, and although made up largely of wings and legs, they seem to be very acceptable food for many species of birds. Representatives of two other families were found in the stomachs.

Lepidoptera, eaten in only four months, and aggregating for the year only 1.21 per cent, are most certainly not a favorite food of the bank swallow. They were found in only five stomachs, of which three contained moths and two caterpillars. One stomach was entirely filled with caterpillars, which were probably snatched from the tops of plants as the bird dashed past.

Orthoptera were identified in the food of the bank swallow by two jaws of a grasshopper in one stomach and one jaw of a cricket in another. This low record is interesting, in view of the fact that so many birds subsist largely upon grasshoppers and allied insects.

Dragonflies (Odonata), being rather large, swift-flying insects, are not preyed upon by many species of birds; but, usually found about water, they naturally fall in the way of bank swallows and form 2.11 per cent of their food. This is not a high percentage, but is notable, as so few birds eat these insects at all. The purple martin (*Progne subis*) is the only swallow that greatly exceeds this record.

A few other insects amount to 10.53 per cent. The great bulk of these consist of May flies (Ephemerida), which are eaten freely, especially in the first of the season. They begin at 43.43 per cent in April and decrease until they finally disappear in August. A few spiders and one snail amount to 0.14 per cent. Besides the foregoing, which may be considered as food, there were found in the stomachs bits of mother of pearl (nacre), bits of eggshell, and pieces of stone, all of which must have been picked from the ground.

Included among the stomachs whose contents have been discussed were those of 28 nestlings all taken from the same colony and at approximately the same time. The food did not differ in any important respect from that of the adults, but 10 stomachs contained angular fragments of stone—not pebbles or gravel stones but broken fragments—taken from a quarry or where macadam was being

manufactured. The number in each stomach ranged from 1 to 4 or 5. For what purpose these stones were given to the nestling birds and why angular fragments were selected can only be conjectured. The food contained in the same stomachs was entirely of insects of a soft nature and did not appear to require the aid of gravel for trituration. Moreover, the parent birds, whose food was certainly as hard as that of the nestlings, did not take anything of the kind into their stomachs.

Following is a list of insects identified in stomachs of bank swallows and the number of stomachs in which found:

ISOPTERA.	
Termes sp	1
HEMIPTERA.	
Entylia concisa	6
Micrutalis calva	3
Micrutalis parva	1
Agallia sp	1
Tetigonia hieroglyphica	1
Cicadula 6-punctata	1
Tylopelta brevis	2
Lygus sp	1
COLEOPTERA.	
Bembidium versicolor	1
Bembidium sp	1
Clivina impressifrons	1
Tachys tripunctata	1
Amara sp	17
Agonoderus pallipes	1
Agonoderus sp	1
Haliplus sp	1
Bidessus affinis	2
Helophorus inquinatus	1
Hydrochus subcupreus	1
Cercyon fulvipennis	1
Cercyon melanocephalum	1
Cercyon sp	7
Cryptopleurum minutum	5
Colon pusillum	1
Atheta sp	1
Cyrtusa blandissima	1
Homalota sp	1
Aleochara sp	2
Heterothops fasculus	1
Philonthus sp	3
Xantholinus obsidianus	1
Cilea silphoides	1
Eustilbus apicalis	1
Phalacrus politus	1
Scymnus loewii	5
Atomaria cphippiata	1
Typhœa fumata	1
Thaumatoglossa americana	1
Hister americanus	1
Hister subrotundus	2
Hister sp	2
Saprinus scissus	1
Saprinus lubricus	1
Saprinus sphæroides	1
Saprinus sp	1

COLEOPTERA—continued.	
Carpophilus dimidiatus	2
Conotelus stenoides	1
Epurœa helvola	1
Cryptarcha strigata	2
Cryptarcha sp	2
Glischrochilus fasciatus	3
Melanophthalma sp	1
Drasterius dorsalis	1
Hyperoides choris	1
Drapetes geminatus	2
Throscus sericeus	1
Cis fuscipes	1
Atœnius cognatus	1
Atœnius sp	1
Onthophagus hecate	1
Onthophagus pennsylvanicus	2
Onthophagus sp	13
Oxyomus porcatus	1
Aphodius fimetarius	6
Aphodius ruricola	1
Aphodius granarius	1
Aphodius vittatus	1
Aphodius punctatus	1
Aphodius inquinatus	24
Aphodius stercorosus	1
Aphodius sp	12
Strigoderma pygmœa	4
Hœmonia nigricornis	30
Diachus auratus	1
Graphops pubescens	1
Metachroma œneicolle	1
Cerotoma trifurcata	2
Epitrix cucumeris	10
Crepidodera helxines	1
Glyptina atriventris	2
Chætocnema pulicaria	3
Chætocnema sp	1
Mylabris prosopis (Bruchus)	3
Notoxus sp	5
Anthicus punctulatus	1
Anthicus floralis	1
Anthicus nitidulus	2
Anthicus sp	10
Thecesternus humeralis	1
Sitona hispidula	27
Sitona flavescens	3
Sitona sp	18
Apion metallicum	2
Apion sp	1
Phytonomus posticus	1

COLEOPTERA—continued.

Macrops sp	1
Balaninus sp	1
Anthonomus grandis	12
Conotrachelus nenuphar	1
Cryptorhynchus bisignatus	2
Hypocœliodes wickhami	1
Cœliodes acephalus	3
Perigaster cretura	1
Limnobaris blandita	1
Baris confinis	1
Baris œrea	2
Rhinoncus pyrrhopus	1
Rhinoncus longulus	1
Centrinus picumnus	2
Calandra oryza	9
Pityophthorus minutissimus	1
Tomicus calligraphicus	1
Tomicus sp	1

COLEOPTERA—continued.

Hylastes tenuis	1
Hylastes sp	2
Hylesinus sp	1
Brachytarsus plumbeus	1

DIPTERA.

Culex sp	1
Calliphora sp	2
Lucilia sp	4

HYMENOPTERA.

Chrysis sp	1
Myrmica scabrinodis	4
Pimpla sp	1
Ophion sp	1
Bassus sp	1
Rhodites sp	1

ROUGH-WINGED SWALLOW.

Stelgidopteryx serripennis.

The rough-winged swallow (Pl. II, middle figure) occupies the United States from ocean to ocean and from the Gulf of Mexico to the latitude of southern New England in the East and of southern Canada in the West. It is not abundant except locally and is found much more frequently in the more southern parts of the country. Its nesting sites are very often like those of the bank swallow; in fact, they may be the old abandoned burrows of that species; but in general they are holes in cliffs, ledges, banks, of earth, or crannies in bridges, and other structures of man. As a rule, rough-winged swallows do not dig holes for themselves. They do not live so much in large colonies as do the other species of swallows, and a pair may frequently be found breeding by themselves, though a colony of five or six pairs is more common. In migration, however, they collect in large flocks.

The following study of the food of the rough-winged swallow is based upon examination of the contents of 136 stomachs, collected in 15 States, the District of Columbia, and Canada, and in the months from April to September. The food was practically all animal matter, except that in one stomach were a lot of woody granules of uncertain origin, in another a piece of root, and in a third two seeds of currant (*Ribes*). In the final analysis these amount to 0.21 per cent and so may be dismissed without further comment. The real food is made up of insects, a few spiders, and a snail. Of the insects, 14.83 per cent are beetles, only 0.5 per cent of which are of useful species. The May-beetle family (Scarabæidæ) (2.69 per cent) were mostly the small dung beetles (*Aphodius*), with a few larger forms. Weevils or snout beetles (4.93 per cent) embrace a few interesting species, as the alfalfa weevil, found in 11 stomachs; the cotton

boll weevil, in 4 stomachs; the rice weevil, and two species of engraver beetle. Among the beetles other than weevils were a number of species of the group commonly known as flea beetles. Some of these are very destructive to garden vegetables and the leaves of fruit trees.

Ants were eaten in every month, but rather irregularly. In July they amount to 35.5 per cent and in September to 22.89 per cent, which together are about four-fifths of this kind of food for the whole season. The total for the year is 11.99 per cent. Other Hymenoptera (18.91 per cent) are eaten regularly and abundantly in every month. They contain the usual admixture of parasitic species, which being abundant are always to be found.

Hemiptera constitute 14.9 per cent of the food and are eaten regularly from May to September. None were found in stomachs taken in April, and more than four-fifths of them were taken in August and September. Ten different families are represented, but stink-bugs, tree hoppers, leaf hoppers, and negro bugs were the most numerous. All of these are more or less harmful.

Diptera are the favorite food of the rough-wing, as they are of most other swallows. They amount to 32.89 per cent, a record that is exceeded only by the tree and barn swallows. They were found in 93 stomachs, 9 of which were entirely filled with them. Flies are such soft-bodied creatures that it is not easy to determine species from the remains found in the stomachs. Five families, however, were identified. In 5 stomachs were recognized members of the family Tachinidæ, composed of parasitic species that live in and destroy caterpillars or other insects, and therefore are useful. Of the remaining four, one family is of no importance, and the others are harmful or at least annoying.

Lepidoptera are eaten sparingly by the rough-wing. The total for the year is 1.11 per cent. All were contained in 5 stomachs, 1 of which was taken in April, 2 in May, and 2 in September. Three of the 5 contained moths, and 2 caterpillars.

Orthoptera are represented in the food of the rough-wing by the fragments of one grasshopper found in a stomach taken in Arkansas on July 5. This made up 16 per cent of the contents of the stomach (0.12 per cent of the food of the year).

Insects belonging to other orders are taken occasionally by the birds. Of these, dragonflies were found in 3 stomachs and May flies in 5. In 5 other stomachs was material so finely mashed as to defy identification beyond the fact that it had once been insects. Fragments of spiders were found in 6 stomachs and a snail in 1. Altogether they amount to 5.04 per cent and close the account of animal food.

Summary.—In the food of the rough-winged swallow the useful elements are as usual in the minority. In this case they consist chiefly of parasitic Hymenoptera, the destruction of which is not a matter of great importance.

Following is a list of insects identified in stomachs of rough-winged swallows and the number of stomachs in which found:

MECOPTERA.	
Panorpa sp	1
HEMIPTERA.	
Entylia concisa	3
Thyreocoris nitiduloides	5
Thyreocoris pulicaria	1
Ophiderma sp	1
Oncometopia undata	4
Corizus sp	3
Nabis sp	1
COLEOPTERA.	
Calosoma calidum	1
Bembidium versicolor	1
Hydroporus modestus	2
Helophorus lineatus	4
Cercyon sp	1
Homalota sp	1
Aleochara bimaculata	1
Philonthus sp	5
Cryptobium sp	1
Oxytelus rugosus	1
Bledius sp	1
Olophrum obtectum	1
Phalacrus politus	1
Hippodamia 13-punctata	1
Scymnus loewii	1
Typhœa fumata	4
Hister abbreviatus	3
Hister subrotundus	4
Hister carolinus	1
Saprinus rotundatus	1
Saprinus sp	1
Carpophilus dimidiatus	1
Epurœa helvola	1
Cryptarcha strigata	4
Cryptarcha sp	1
Glischrochilus fasciatus	10
Glischrochilus sp	2
Limnichus nitidulus	1
Heterocerus sp	1
Cregya oculata	1

COLEOPTERA—continued.	
Onthophagus pennsylvanicus	5
Onthophagus sp	8
Aphodius inquinatus	18
Aphodius sp	18
Diachus auratus	1
Nodonota tristis	1
Cerotoma caminea	5
Cerotoma trifurcata	1
Galerucella sagittariæ	1
Epitrix fuscula	1
Crepidodera velutinus	1
Chætocnema denticulata	1
Chætocnema pulicaria	1
Chætocnema sp	1
Anthicus biguttulus	1
Anthicus sp	5
Rhipiphorus dimidiatus	1
Phytonomus posticus	11
Anthonomus grandis	4
Orchestes vittata	2
Rhinoncus pyrrhopus	1
Ceutorhynchus rapæ	3
Baris sp	1
Calandra oryza	1
Sphenophorus sp	2
Platypus flavicornis	1
Rhyncholus sp	1
Tomicus calligraphus	3
Tomicus cacographus	1
Hylastes tenuis	1
Hylastes exilis	1
Brachytarsus sp	1
DIPTERA.	
Bibio sp	1
Morellia micans	1
Tachina sp	5
HYMENOPTERA.	
Andrena sp	1
Lasius sp	2
Formica fusca	1

TABULAR SUMMARY.

The following table shows the relative proportions of the most important elements of the food of the seven species of swallows:

Food items.	Purple martin.	Cliff swallow.	Barn swallow.	Tree swallow.	Violet-green swallow.	Bank swallow.	Rough-winged swallow.	Average for the seven species of swallows.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Weevils	2.63	8.38	1.96	1.92	4.12	5.78	4.93	4.25
Other beetles	9.90	18.50	13.66	12.50	6.45	12.12	9.90	11.86
Ants	3.52	8.24	9.89	6.37	9.42	13.39	11.99	8.97
Other Hymenoptera	19.47	20.51	12.82	7.58	17.48	20.10	18.91	16.70
Hemiptera	14.58	26.32	15.10	5.59	35.96	7.96	14.90	17.20
Diptera	16.09	13.25	39.49	40.54	19.36	26.63	32.89	26.89
Lepidoptera	9.39	.46	2.39	1.07	3.12	1.21	1.11	2.68
Orthoptera	1.09	.71	.51	.38	.....	.01	.12	.40
Other insects	22.87	2.56	3.72	4.25	4.09	12.64	4.48	7.80
Other animal food	.46	.41	.28	.34	.....	.14	.56	.31
Vegetable food	.....	.66	.18	19.46	.....	.02	.21	2.93

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 620

Contribution from the Forest Service
HENRY S. GRAVES, Forester

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EFFECT OF VARYING CERTAIN COOKING CONDITIONS IN THE PRODUCTION OF SULPHITE PULP FROM SPRUCE.

By S. E. Lunak, *Chemist in Forest Products.*

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PURPOSE OF THE EXPERIMENTS.

Forest products investigations of the Forest Service include the study of problems connected with the manufacture of pulp and paper from wood, so as to utilize waste material from the lumber and other industries wherever possible, to increase the efficiency of present methods of making pulp, and to determine the practicability of making pulp from woods hitherto little used or considered unfit. Bulletins have been issued on the soda, sulphate, and ground-wood processes showing the effect which the different fundamental variables have on the resultant pulp. This bulletin supplies similar information for the sulphite process, and shows what effect the amount of combined sulphur dioxide (SO_2), the total sulphur dioxide, and the temperature have upon the color of the paper, the duration of the cooking period, the yield of pulp and screenings, and the consumption of bleach.

The original patent for the making of sulphite pulp states that it can be produced with or without the addition of a base to the cooking liquor but that a lighter product can be obtained when a

Note.—Acknowledgement is made to Mr. O. L. E. Weber, formerly of the Forest Products Laboratory, and Dr. Otto Kress, in charge of the section of pulp and paper, Forest Products Laboratory, for many valuable suggestions and much helpful advice.

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base is present. Lime is the base in most common use. For a long time it was not known how much of this was necessary to make good pulp, most mills simply taking the acid that their systems gave them. Many are still following that practice. Most mills have a good idea of how the different factors affect their cooking, but there is no published report on the subject. It was to furnish detailed information on just how much each of the various factors influences the cooking and to supply a basis for future experimental work that this investigation was undertaken.

THE SULPHITE PROCESS.

The inventor of the sulphite process, Benjamin C. Tilghman, of Philadelphia, took out a patent in the year 1867, in which he describes a method of boiling under pressure wood or other vegetable material in a solution containing sulphurous acid, with or without the addition of sulphites, until a fibrous product is obtained suitable for the manufacture of paper. The foundation of the sulphite pulp industry rests upon these patents; yet Tilghman had to abandon his process because his financial backers withdrew their support upon finding out that sulphurous acid corrodes iron and that the inventor was having difficulty in obtaining a suitable lining for his digester when he tried to work his process on a large scale.

For some time this difficulty hindered the development of the process. In 1886 cement and special brick linings were introduced in some mills and gave such good satisfaction from the start that it was not long before they were universally adopted. The solution of this problem insured the commercial success of the sulphite industry, and from this time on it has had a rapid growth, until now it is the most important pulp making process in the United States, as is shown by the figures in Table 1 taken from the census reports.

TABLE 1.—*Quantity of wood pulp produced in the United States.*

Process.	1890	1899	1909	Value (1909).	1916	Value (1916).
	Tons.	*Tons.*	*Tons.*		*Tons.*	
Sulphite	59,686	417,646	1,027,012	$44,600,000	1,306,217	$60,702,459
Soda	87,853	172,142	287,945	12,770,000	183,106	8,251,219
Ground wood	290,158	568,284	1,201,832	25,200,000	1,505,547	32,547,704

KINDS OF WOOD USED.

In the early days spruce was almost the only wood used in making sulphite pulp, but it was not long before hemlock and balsam began to be used extensively. At the present time some mills are cooking tamarack and poplar, and on the west coast white, red, amabilis, and grand fir, sitka and Engelmann spruce, western hemlock, and other woods are finding favor. No doubt it will not be long before

many other woods will be used, as spruce is becoming too expensive. The sulphite process can not be used on woods that contain much pitch, because a large part of the pitch remains in the pulp and later causes much trouble on the wires of the paper machine. This problem has been the subject of much study and investigation but no successful method has yet been found for cooking such wood by this process and eliminating the resin.

The curves in figure 1 show the per cent of the principal woods used in the sulphite process from the year 1900 to 1911. The consumption of spruce is decreasing, and other woods are being used more

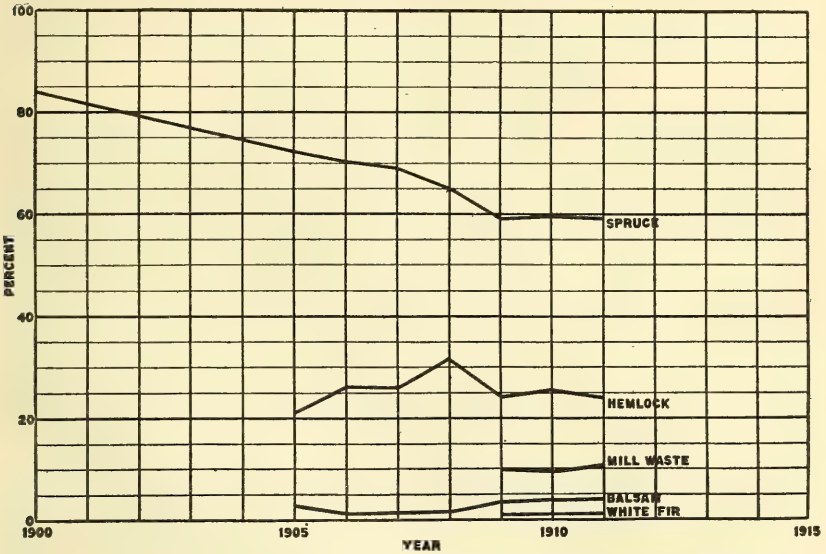


FIG. 1.—Consumption of wood by the sulphite process in the United States, 1900–1911.

extensively than before. Table 2 gives in detail the kind and amount of each wood used.

TABLE 2.—*Consumption of wood by the sulphite process in the United States.*

[From Census and Forest Service Reports.]

Kind of wood.	1900		1905		1906		1907	
	Cords.	Per cent.	Cords.	Per cent.	Cords.	Per cent.	Cords.	Per cent.
Spruce	790,153	83.9	1,176,930	72.2	1,374,212	70.2	1,422,400	69.1
Hemlock	.....	.....	344,579	21.1	516,512	26.4	541,113	26.2
Poplar	.....	.....	.....	.....	.....	.....	1,536	.1
Balsam	.....	.....	45,943	2.8	22,314	1.1	28,356	1.4
Pine	.....	.....	18,606	1.1	3,600	.2	3,200	.2
White fir	.....	.....	.....	.....	.....	.....	.....	.....
Slab wood and other mill waste	.....	.....	.....	.....	.....	.....	.....	.....
All other species	152,364	16.1	44,341	2.8	41,981	2.1	62,890	3.0
Total	942,517	.....	1,630,393	.....	1,958,619	.....	2,059,495	.....

TABLE 2.—*Consumption of wood by the sulphite process in the United States*—Continued.

Kind of wood.	1908		1910		1911		1916	
	Cords.	Per cent.	Cords.	Per cent.	Cords.	Per cent.	Cords.	Per cent.
Spruce	1,131,377	65.2	1,332,153	59.5	1,391,047	59.2	1,803,217	63.1
Hemlock	544,131	31.4	574,109	25.6	563,535	24.0	647,738	22.7
Poplar	3,734	.2	625	.....	4,101	.2	2,991	.1
Balsam	24,761	1.4	81,932	3.7	100,339	4.2	213,569	7.5
Pine	3,484	.2	4,720	.2	4,286	.2	8,209	.3
White fir	.....	.....	27,797	1.2	32,498	1.4	35,865	1.3
Slab wood and other mill waste	.....	.....	219,519	9.7	254,914	10.8	140,758	4.9
All other species	28,772	1.6	1,285	.1	830	.....	3,775	.1
Total	1,736,259	.....	2,242,140	.....	2,351,550	.....	2,856,122	.....

PRESENT METHODS OF OPERATION.

At the present time there are used in this country two general methods of cooking sulphite pulp, the short and the long, or so-called Mitcherlich, depending on the product it is desired to obtain. The preliminary preparation of the wood is the same for both of these processes. The wood reaches the mill in the log and is then sawed up, usually into 2-foot bolts. These are barked by machine or drum barkers, care being taken that all portions of the bark are removed, because it discolors the pulp. The wood is next reduced to chips, which are put through screens to remove all above and below a certain size. It is very desirable to have them uniform. They are then conveyed to storage bins above the digesters and used as needed.

In the short cook the digester is filled with chips and cooking liquor, and by means of live steam which enters at the bottom the pressure in it is brought up to 75 or 80 pounds as quickly as possible. The pressure is then kept at this point and the temperature is gradually raised, so that a temperature of 154° C. is reached at the end of about 7 to 9 hours. While the temperature is being raised, the SO_2 gas which is being driven from the liquor in the digester is constantly relieved and reclaimed by absorption directly in tanks or in towers filled with stone. The pressure in the digester is due partly to the steam present and partly to the gas liberated. As the cook progresses the steam pressure increases, but the gas pressure decreases until at the end of the cook there are only a few pounds of pressure due to the SO_2 gas present. The pressure in the digester is kept the same by means of an automatic arrangement, which lets in more steam when the digester is being relieved and shuts it off again when the relief valve is closed. At the end of 3 or 4 hours the condensation in the digester causes it to fill up with liquor, which is relieved usually through an opening about 3 feet from the top. Toward the end of the cook the liquor in the digester gets darker and darker until it reaches a light coffee color. The end point is determined by the color

and smell of the liquor, and how accurately it is attained depends in most mills wholly on the experience and judgment of the man in charge of the cook. When the cook is finished, a large valve is opened at the bottom of the digester and the contents blown through a pipe into a blow pit, where they are thoroughly washed.

In the slow cook process the digester is heated by lead coils placed in the bottom. Because of the caking of calcium monosulphite on them, however, these are rapidly going out of use and the heating is being done by direct steam. A somewhat weaker acid is used than for the short cook, and the pressure is held at from 60 to 65 pounds. A cook lasts from 20 to 30 hours, but the digesters are much larger than in the quick-cook process and the pulp is much stronger and the fibers longer. Otherwise the process of cooking is the same.

PLAN OF TESTS.

In the experiments recorded in this bulletin, the following factors were studied for the effect of variations in them on duration of cooking, yield of pulp, yield of screenings, bleach consumed, color of pulp produced, and strength.

1. Ratio of free to combined sulphur dioxide, or the amount of lime in the cooking liquor.
2. Total sulphur dioxide.
3. Temperature of cooking.

While one factor was studied the other two were kept as constant as possible. For instance, when the effect of temperature was being studied, cooks were made with definite variations in temperatures, but the consumption of the cooking liquor remained the same. Of course, the following factors were kept constant for all the cooks: Amount of chips, 74.2 pounds bone dry; moisture condition of chips, air dry; amount of acid, 63 gallons; time to reach 100° C., 2 hours; time to reach maximum temperature, 3 hours.

APPARATUS.

A plan of the apparatus used in cooking is shown in figure 2. The digester was lined with a half and half mixture of special cement and quartz sand. This lining was about 1½ inches thick, and on top of it was put a layer of pure cement 1 inch thick.

The equipment used for making the pulp into paper consisted of a pulp shredder, 15-pound Emerson beater, 6-plate diaphragm screen with 0.009-inch slots, and a 15-inch Fourdrinier paper machine. A 50-pound Marx beater was used on the last six cooks.

The wood used in these experiments was white spruce (*Picea canadensis*) cut in the State of Wisconsin. This wood was cut into five-eighths-inch chips in a small chipper of the usual design and the chips screened, after which they were ready for the digester.

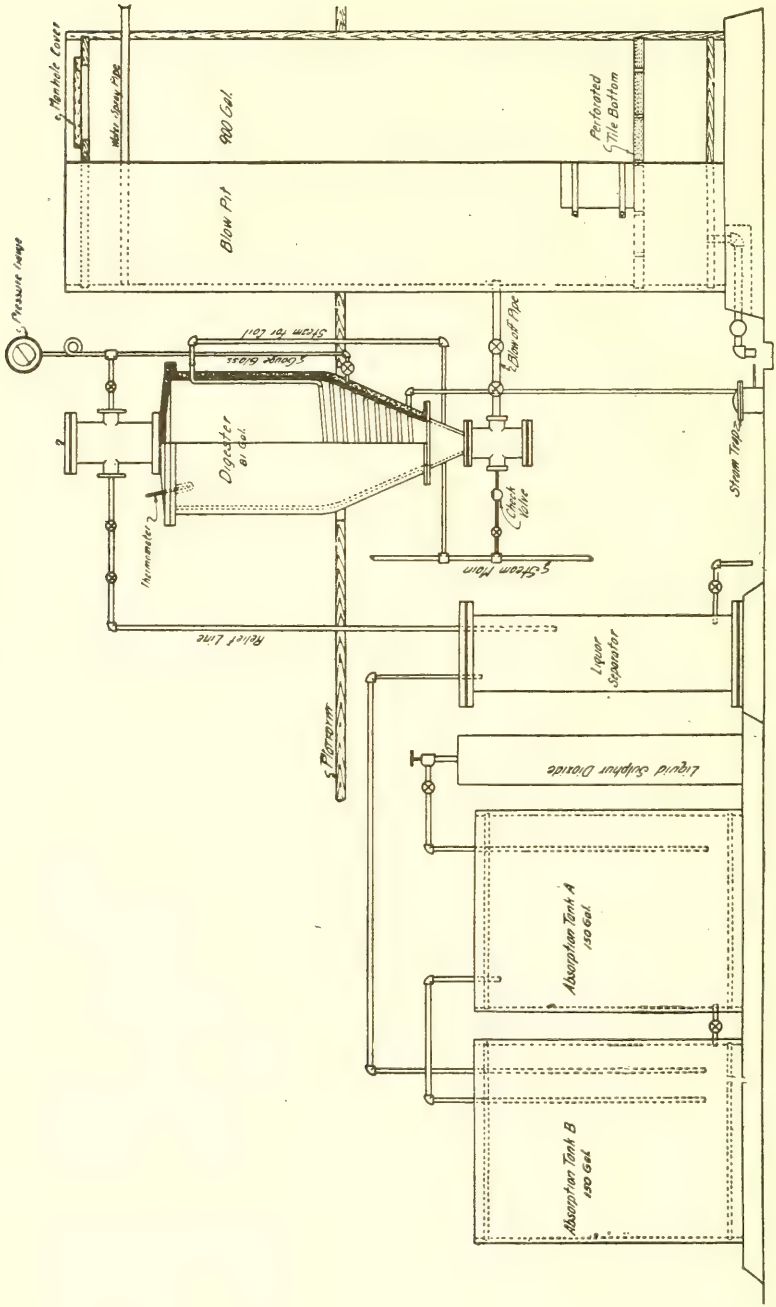


FIG. 2.—Plan of apparatus used in cooking.

METHOD OF CONDUCTING EXPERIMENTS.

LIQUOR MAKING.

The sulphur dioxide used in making the liquor in these experiments was obtained in liquid form under pressure in iron cylinders 5 feet 5 inches in height and 11 inches in diameter, each cylinder holding about 200 pounds. By obtaining the sulphur dioxide in this way the cooking liquor can be made to any desired strength in a couple of hours by simply turning a valve, which is an ideal way of handling the gas for experimental work.

In making the cooking liquor for the first cook the gas from one of these cylinders was passed to the bottom of an absorption tank, containing the desired amount of milk of lime, by means of a lead pipe which contained a number of small openings in the end. The procedure in making the subsequent liquors was as follows: When a cook was finished, the pressure in the digester was blown down to about 65 or 70 pounds, and the gas thus liberated was passed through a separator, which removed the liquor, to the bottom of the absorption tank B (fig. 2) which contained a dilute solution of milk of lime. The liquor from tank B (fig. 2) was then pumped to the make-up tank A (fig. 2) and, if necessary, water was added so that it contained at least 80 gallons. Sulphur dioxide gas was then passed into this tank from the cylinder and the liquor in the tank analyzed (for methods of analysis see p. —) every half hour. The rate at which the gas was being absorbed could then be calculated and the time in which the desired strength would be obtained could be determined very closely. The cylinder could also be put on a scale and the desired amount of gas calculated and the weight obtained by difference. After the tank B (fig. 2) was emptied it was again filled with a dilute solution of milk of lime [1] and any gas that was not absorbed in the make-up tank passed through a lead pipe back into this tank. Very little gas would be given off, however, it being absorbed almost up to the full pressure of the cylinder. While the gas is being absorbed in the make-up tank, milk of lime can be added as desired or cooking liquor can be made containing no lime at all. When the liquor is of the desired strength it is ready to be pumped to the digester to start the next cook.

While these experiments were in progress it became impossible to secure a supply of liquid sulphur dioxide, and in order to continue it became necessary to make the gas. A description of some of the methods tried may be of assistance to anyone contemplating doing experimental work along this line.

---

[1] The lime used in the experiments had the following analysis:

SiO_2	0.56	MgO	32.31
Fe_2O_3&Al_2O_3	1.20	CO_2&H_2O	1.90
CaO	64.19		

The first method tried was the ordinary one of burning sulphur and passing the gas through a milk of lime solution. A small sulphur stove, with a flat bottom and a burning area of about 3 square feet, was designed. The gas, after leaving the stove, passed through a cooling system and through three absorption tanks of about 150 gallons capacity, so arranged that it entered the bottom of the first tank, the unabsorbed portion then passed to the bottom of the next tank, and so on to the third one, the gas being moved by suction. The two tanks nearest the stove contained water alone and the last one milk of lime. After the system had been going for about three hours, samples were taken from each tank and analyzed. The liquor in each of the first two tanks contained about 1.20 per cent of SO_2 and in the last tank 3.10 per cent, all of it calcium bisulphite; nor could the solutions be made any stronger by continuing the operation, the gas simply passing through without being absorbed. The reason that the solutions would not become stronger is that the solubility of SO_2 gas depends on its dilution. Pure SO_2 gas is very soluble in water, it being possible to make solutions containing as high as 10 per cent; but just as soon as it is diluted with some other gas that is not soluble in water, such as nitrogen, the strength of the solutions becomes much less. Thus, the gas produced here contained about 17 per cent SO_2 and would produce only a certain strength of solution no matter how long the gas was passed through; the solutions became even weaker if the fire in the burner got low. As solutions had to be made to meet a wide range of concentrations, this method was abandoned.

It was then decided to absorb the gas in two towers, 15 feet in height and 15 inches in diameter, made of sewer crock, and filled with broken tile, to see how strong a solution could be obtained by absorbing the gas in pure water alone. The gas from the burner entered the first tower at the bottom and met water trickling down through the broken tile, left it at the top, and passed into the bottom of the next tower. The strongest acid in the first tower contained 2.20 per cent SO_2 and the second 1.10 per cent. As this acid was not strong enough, it was decided to pump the acid from the towers into the digesters, there drive off the gas by heat and reabsorb it in one of the tanks. While acid by this method could be brought to any desired strength, it took so much time and attention that it was not practical.

The next method tried was to secure the action of sulphuric acid upon sodium bisulphite according to the equation $2NaHSO_3 + H_2SO_4 = Na_2SO_4 + 2SO_2 + 2H_2O$. For this purpose, a 16-inch pipe, 4 feet long, was flanged at both ends and lead-lined. The desired amount of sodium bisulphite mixed with water was fed in through an opening in the upper flange, which was then closed. The sulphuric acid was

fed in through a U-tube, the receiving end (which was about 5 feet higher than the top of the cylinder) having a large lead dish attached, into which the sulphuric acid was poured. As the sulphuric acid mixed with the sodium bisulphite, pure sulphur dioxide was liberated. This was passed through a Woulf bottle, containing a little water as a trap to catch any sulphuric acid which might boil over. From here the gas entered the absorption tank. As the gas produced was pure, sulphur dioxide solutions of any strength desired could be produced.

Making the cooking liquor was not so quick or easy, nor was it so simple and convenient with the gas as with the sulphur dioxide in liquid form, so that the liquid was again used as soon as a supply was once more available.

METHOD OF COOKING.

The method of cooking received a great deal of consideration, as one variable, the pressure, was hard to control. The ordinary method of cooking by direct steam and relieving sulphur dioxide at the top is unsuitable for experimental cooking because, first, direct heating causes too much condensation of steam in the digester with consequent dilution of the cooking liquor and, second, relieving SO_2 at the top would have a tendency to destroy the effect which we were trying to study. For example, in studying different strengths of cooking liquor, there would be no object in starting with a strong liquor, only to blow all the sulphur dioxide out of the digester in a short while. Therefore it was decided to heat the digester by means of indirect steam, that is, by means of a lead coil placed in the bottom of the digester; and no gas was allowed to escape until the cook was finished. While this method of cooking differs from that used in commercial practice, it will bring out more than any other the factors under investigation.

The method of procedure in making a cook was as follows: The chips, the amount of which had previously been determined by means of a bone-dry sample, and which remained the same for every cook, were put into the digester and 63 gallons of cooking liquor in each case were then run in and the digester tightly closed. The steam to the coil was then turned on and the cook started. The cooking curve for temperature was the same in each case, taking two hours to reach 100° C., and three hours to reach the maximum temperature, where it was held until it was finished, the pressure being allowed to go where it would. Keeping the full strength of the liquor to the finishing point in this way gave a hard pulp, which had the characteristics resulting from beating for a long time.

The curves for all cooks are shown in figures 3 to 7. In each figure, curve 1 shows the way the temperature was increased and

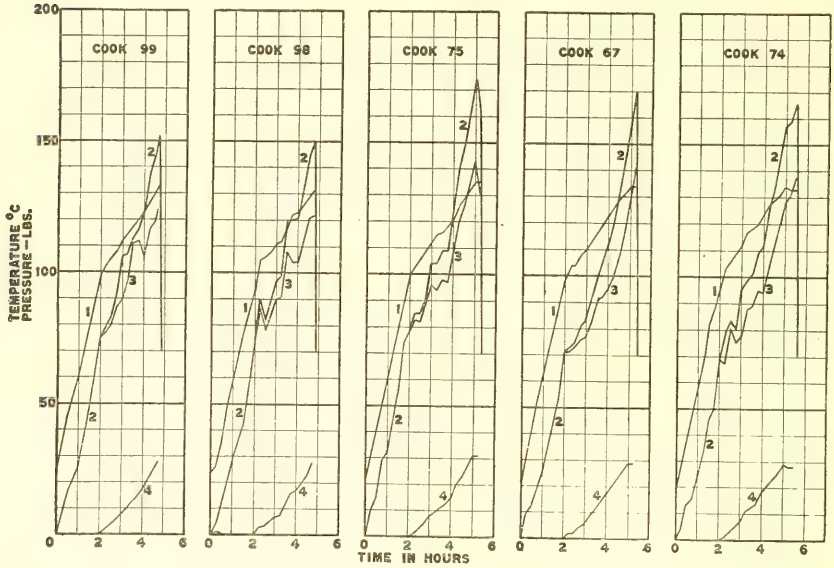


FIG. 3.—Cooking curves for cooks 99, 98, 75, 67, and 74. 1, temperature; 2, gauge pressure; 3, gas pressure; 4, steam pressure.

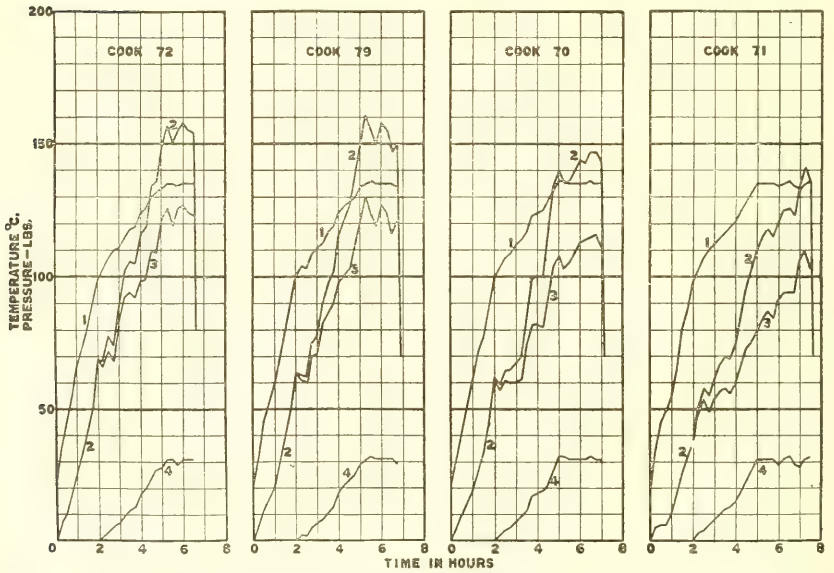


FIG. 4.—Cooking curves for cooks 72, 79, 70, and 71. 1, temperature; 2, gauge pressure; 3, gas pressure; 4, steam pressure.

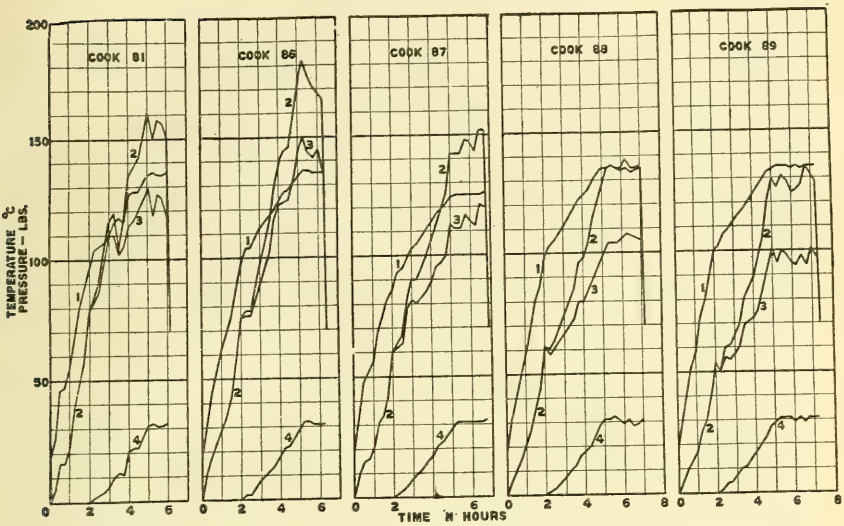


FIG. 5.—Cooking curves for cooks 81, 86, 87, 88, and 89. 1, temperature; 2, gauge pressure; 3, gas pressure; 4, steam pressure.

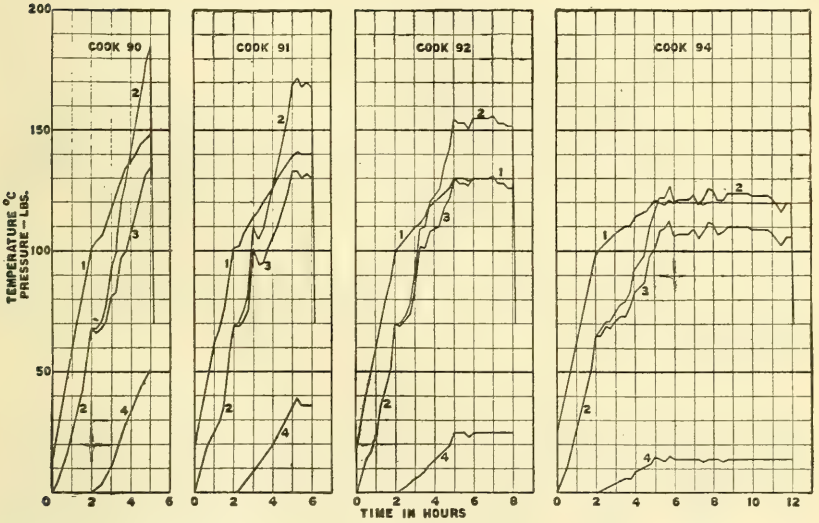


FIG. 6.—Cooking curves for cooks 90, 91, 92, and 94. 1, temperature; 2, gauge pressure; 3, gas pressure; 4, steam pressure.

curve 4 shows the steam pressures corresponding to the temperatures. Curve 2 shows the gauge pressure, and curve 3 shows the gas pressure, which is the difference between the gauge pressure and the steam pressure at any given point. Endeavor was made to keep the temperature curve a straight line, but sometimes the temperature would drop and then to reach the desired temperature the observer would turn on full pressure of steam, which caused a rapid increase in the gauge pressure and accounts for some of the bulges in the gas and gauge pressure curves. Every 15 minutes readings were taken of the temperature and pressure. Owing to the peculiar type of construction of the digesters and the position of the thermometer well, it was necessary at the end of about two and one-half hours of cooking to inject steam into the digester to make up for the liquor taken up by

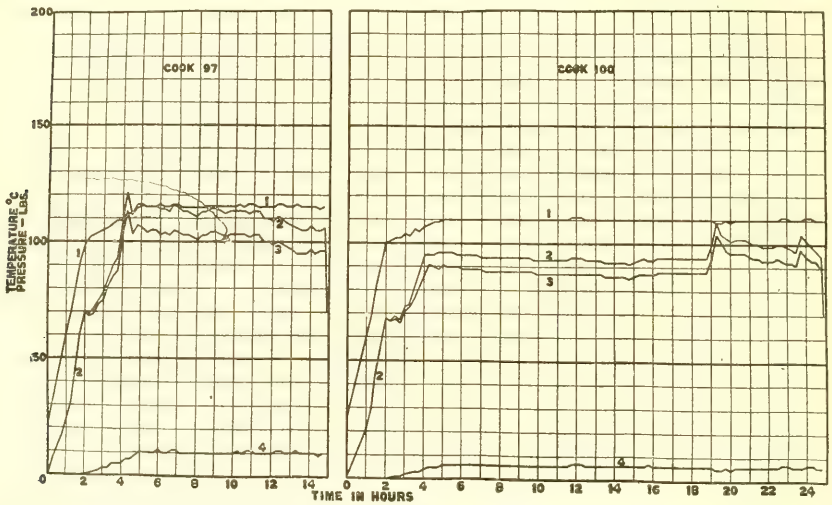


FIG. 7.—Cooking curves for cooks 97 and 100. 1, temperature; 2, gauge pressure; 3, gas pressure; 4, steam pressure.

the chips, or the liquor level would sink below the thermometer well and not give the correct reading. This was done as uniformly as possible for every cook.

METHOD OF FINISHING COOK.

With the composition of liquor and temperature changing each time, a great deal of difficulty was experienced at first in knowing when to finish cooks so that each one would be pulped to the same degree. The digester was equipped so that cold liquor for sampling could be obtained by passing it through a condenser.

An attempt to finish cooks to the same sulphur dioxide content was made, but some would be overcooked while others would be almost raw, as a result of using liquor containing different amounts of SO_2. This method can only be used when the same kind of liquor

is used for every cook. What is ordinarily known as the lime test was also tried. In this test some of the cooking liquor from the digester was put in a test tube containing a slight excess of ammonia, and if the lime came down in a dark floculent condition it was time to blow the cook. While this method gave promise, the results obtained with it were very erratic and it was finally abandoned. An attempt to judge the degree to which the chips in the digester had been cooked by blowing some out into a canvas bag and shaking in a cylinder was also unsuccessful because of the great irregularity in the samples. Sometimes a sample would show more uncooked shives than the one taken half an hour before. Judging the condition of the stock by dyeing with a basic color, such as diamond green, also showed no regularity. Nor did the depth to which a 13 per cent solution of nitric acid would color the pulp indicate the end point accurately.

It is common practice in pulp mills to judge when a cook is finished by the color, smell, and analysis of the liquor; but with the wide variety of conditions under which the cooks in this study were made it was at first thought that these methods would not be applicable. However, it was decided to give the color method a trial. The liquor in the digester near the end of the cook has a light caramel color which darkens rapidly on standing.

To finish a series of cooks to the same degree of cooking it is necessary to have some fixed color as a standard for comparison. Most solutions of organic dyes change in color rapidly when exposed to the light and no combination of mineral dyes could be made that would match the color wanted close enough. The color desired strongly resembles the color of coffee extract, and it was decided to see if this could not be made permanent enough to run a series of cooks. Two solutions, which had been clarified with the white of an egg, were made, one light and one dark, and the shade desired was matched up as closely as possible by mixing the two. Formaldehyde solution was then added to stop fermentation and no change in color of the coffee extract was perceptible, even after it had been in use for several months. The results obtained by using this standard were satisfactory from the first. All that is necessary to duplicate a certain cook is to match the color of the liquor at time of finishing with coffee extract to be used as a standard. This ought to find application commercially, as the man in charge will not have to depend on his memory when he wishes to duplicate a certain cook. During the progress of the cook, samples of the liqour were withdrawn from time to time in a test tube and the color compared with the standard. When the color matched, the steam to the coil was turned off, the pressure in the digester relieved to 70 pounds in five minutes, and the cook blown into the blow pit.

METHOD OF HANDLING PULP.

The blow pit was fitted up with a false bottom made of perforated tile. The pulp was washed five or six times with water and allowed to drain each time. When it had been sufficiently washed, it was shoveled out into a canvas bag, placed in a perforated iron cylinder, and then pressed in a 70-ton knuckle joint power press until it was about 30 per cent dry. It was then shredded, so that the bone-dry weight determination could be made accurately, weighed, and sampled for moisture determination. The pressing operation caused the pulp to ball or stick together, so that it had to be opened up in the beater before it could be screened. This was done with the roll well up, after which it was pumped to a stock tank and diluted with water. From here it ran upon a six-plate diaphragm screen with slots 0.009 of an inch in width. After being screened it ran through a stock thickener, where most of the water was removed. The screenings were carefully collected, pressed, weighed, and sampled for moisture determination. Some of the screened pulp was saved for bleach and other determinations, after which it was put into a 15-pound Emerson beater, mixed with water and beaten, with the roll off the bed plate, for one-half hour. The stock was then run into paper over a 15-inch Fourdrinier machine and samples of the uncalendered sheets taken for strength tests.

The methods of making the bleach, yield, and strength determinations are given on page 22.

EFFECT OF VARYING THE RATIO OF FREE TO COMBINED SO_2 OR THE AMOUNT OF LIME IN THE COOKING LIQUOR.

In order to determine the effect of varying the ratio of free to combined SO_2, cooks were made using a liquor with a total sulphur dioxide content of 5 per cent and a maximum temperature of cooking of 135° C., the amount of SO_2 combined with lime being varied from 0.30 to 2.09 per cent. The curves in figure 8 show how variations in the combined SO_2 affected the color rating, duration of cook, yield of screened and unscreened pulp, yield of screenings, and bleach consumption.

A decrease in the combined SO_2, other conditions being constant, has a tendency to shorten the duration of the cooking time. Increasing the amount of combined SO_2 to 1 per cent has a tendency to make the pulp lighter, but the color remains constant when the combined SO_2 is increased over 1 per cent. The color determinations for the machine-made sheets were made by means of a tint photometer (p. 22). The higher the parts black, the darker the sheet.

The yield of screenings and unscreened pulp remains constant when the combined SO_2 is decreased to 1 per cent, but any decrease below this shows a sharp increase in both of these factors. The

yield of screened pulp increases as the combined SO_2 is increased to 1 per cent, but beyond this remains constant. The amount of bleaching powder necessary to bring the pulp to a standard white decreases as the combined SO_2 is increased to about 1 per cent, but

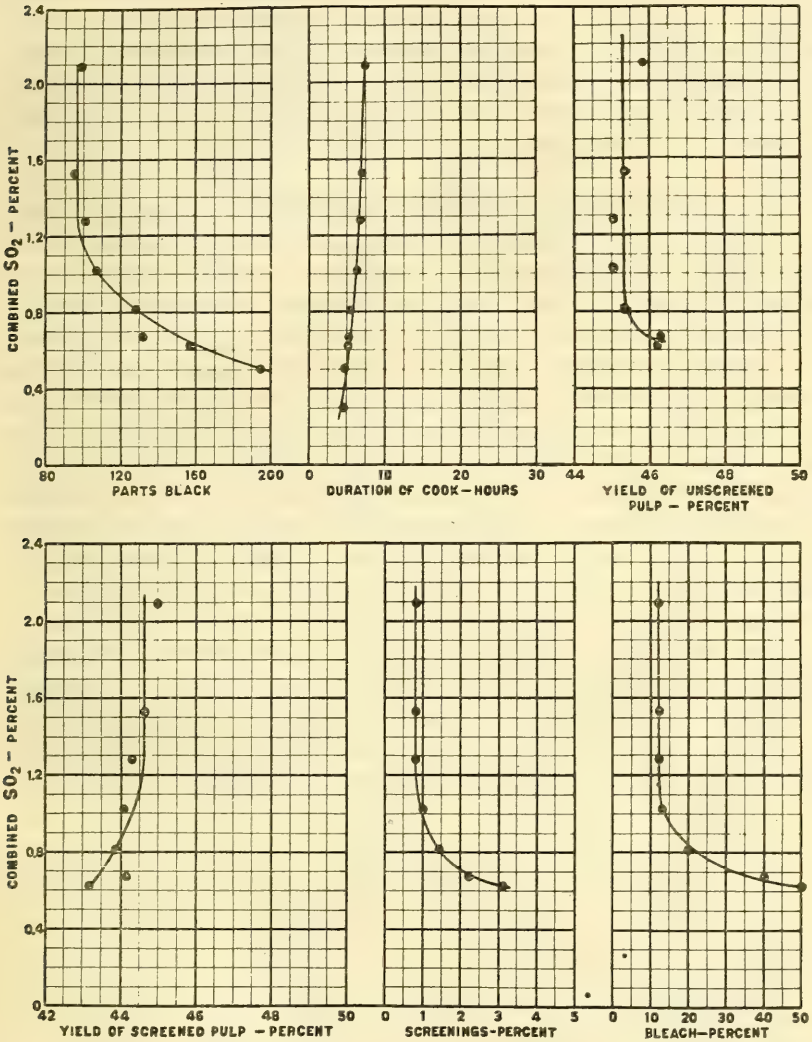


FIG. 8.—Effect of varying the amount of combined SO_2 in the cooking liquor.

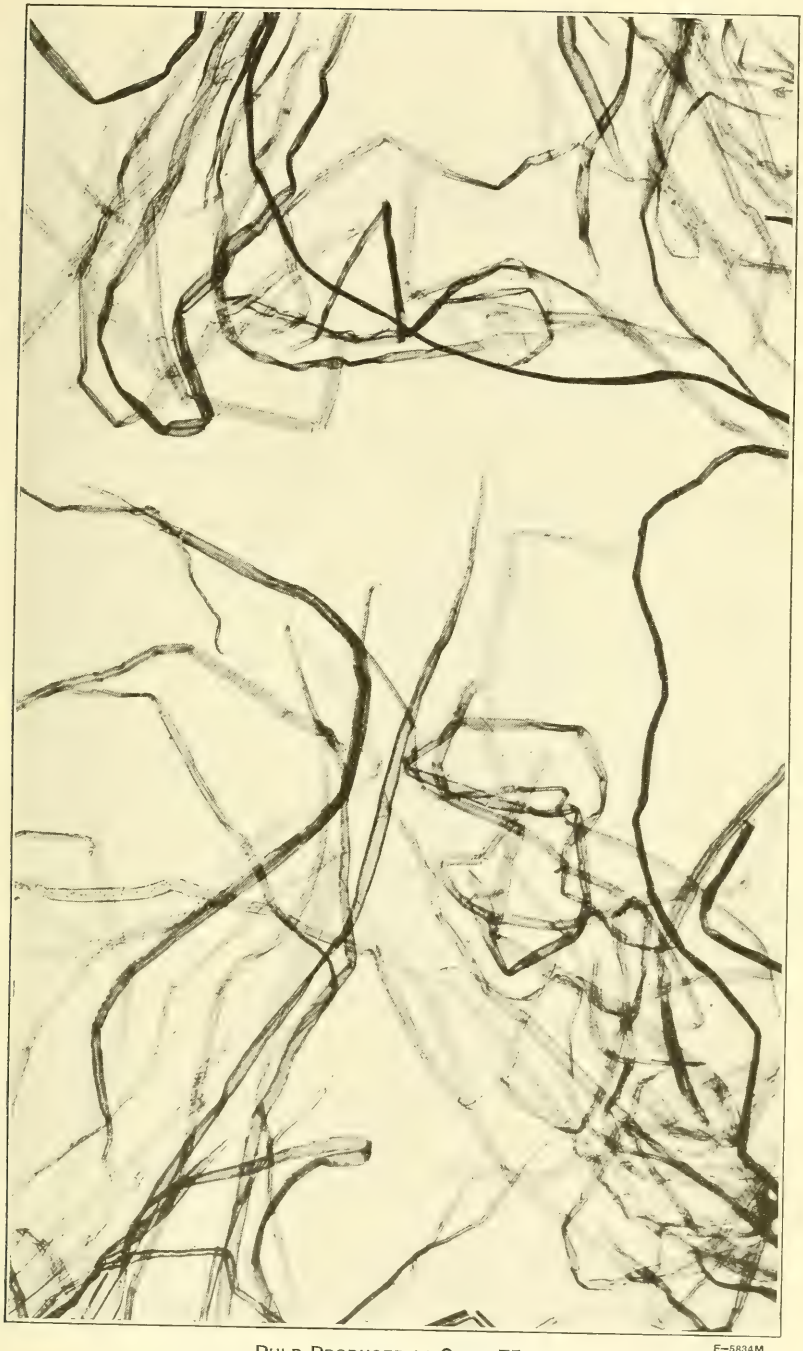
any increase beyond this point does not produce any further change in color.

The amount of combined SO_2 does not seem to have much influence on the different factors studied, provided it is over 1 per cent, but any decrease below this caused marked changes in the character and

yield of pulp. One cook was made where the cooking liquor contained only 0.30 per cent of combined SO_2, and the result was that the chips came out of the digester looking as if they had received only a steaming treatment. They were softened, but black, and gave a yield of 60.40 per cent, showing that the wood had not been thoroughly cooked. When the combined SO_2 is decreased too much, there is a darkening of the liquor without the corresponding cooking action, causing a browning of the pulp. Apparently a certain amount of lime must be present in the cooking liquor to get complete pulping, but its effect becomes less as it is increased beyond 1 per cent combined SO_2.

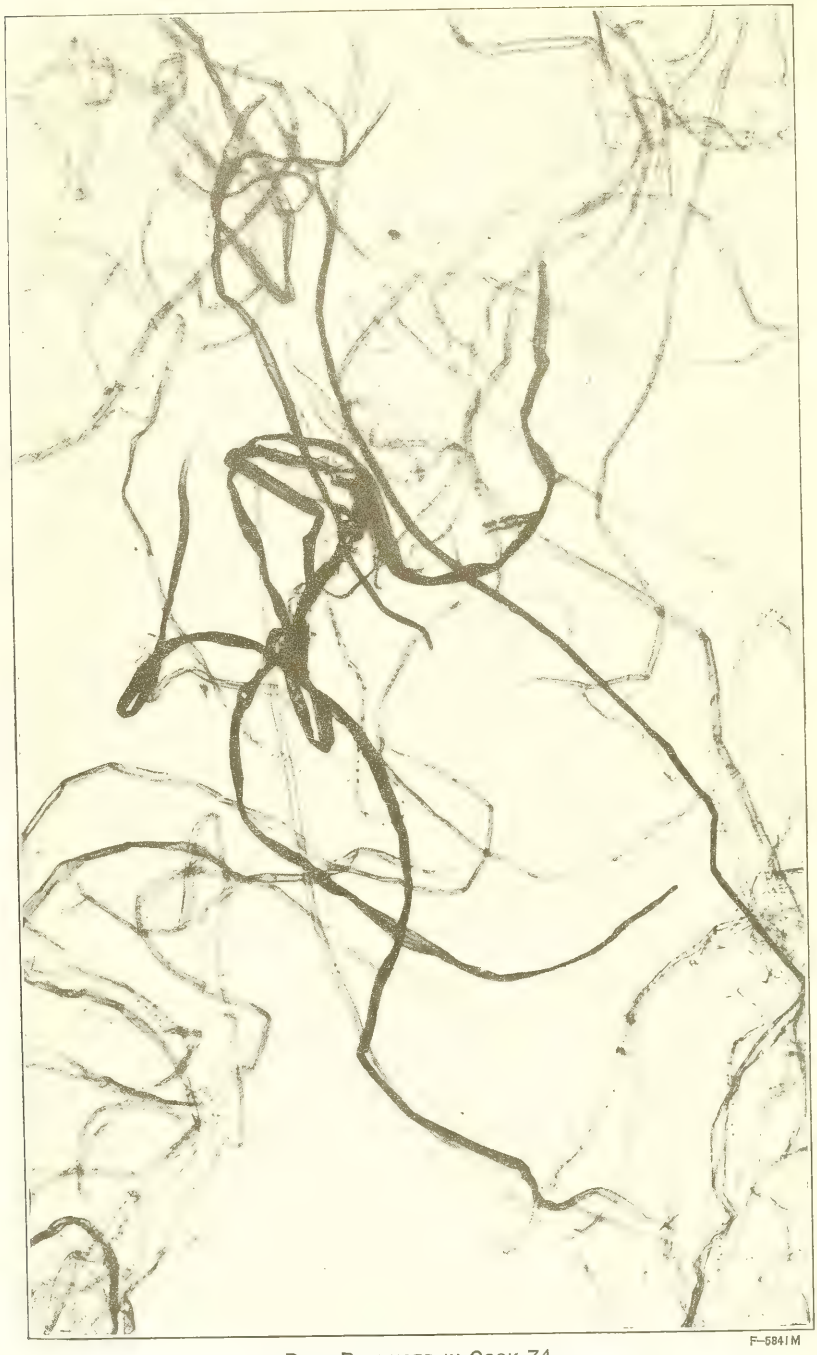
At the present time, the only method of giving a numerical value to the strength of the fibers of a pulp is to make strength tests of paper produced from that pulp. In order to obtain any regularity of results in strength of paper in a series of tests it is necessary that the beating of the pulp, formation of the sheet, heat in the driers, humidity at which the strength tests are made, and probably other factors must remain constant. Most of these, then, depend on the personal equation of the machine tender, and where some of the runs may be made a week apart, conditions are likely to vary. This probably explains the irregularity of the strength results as given in Table 3. If they show anything at all, it is that above 0.80 per cent the amount of combined SO_2 has no influence on the strength of the paper produced but below that there is a tendency to decrease in strength.

Photomicrographs of the pulps secured in cooks 75, 74, 72, and 71 are shown in Plates I, II, III, and IV. It will be noted that there is a gradual change in the appearance of the fibers. Cook 75 was made with liquor containing 0.62 per cent of combined SO_2, and cook 71 with 2.09 per cent. The former contains much lignified fiber, while the latter seems to be thoroughly cooked.



PULP PRODUCED IN COOK 75.

F-5834M



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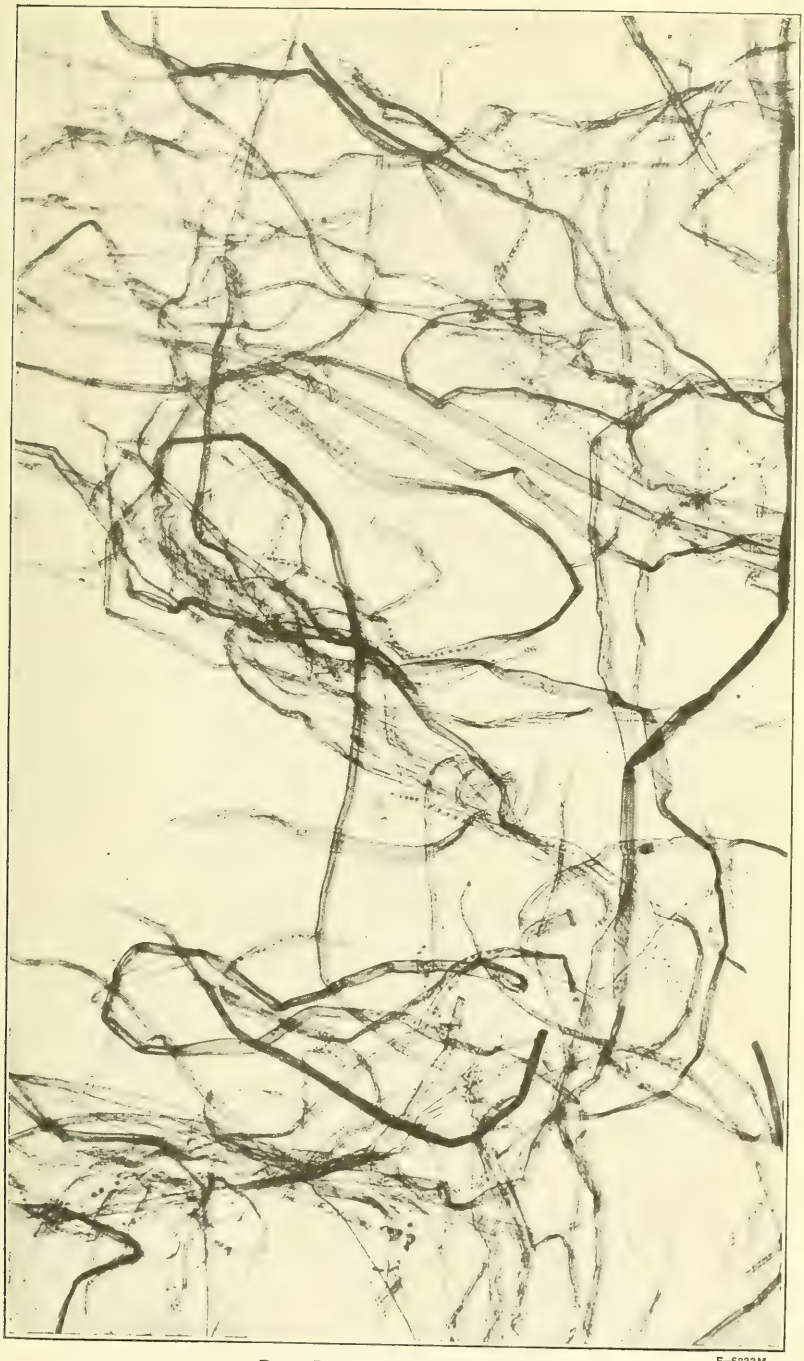
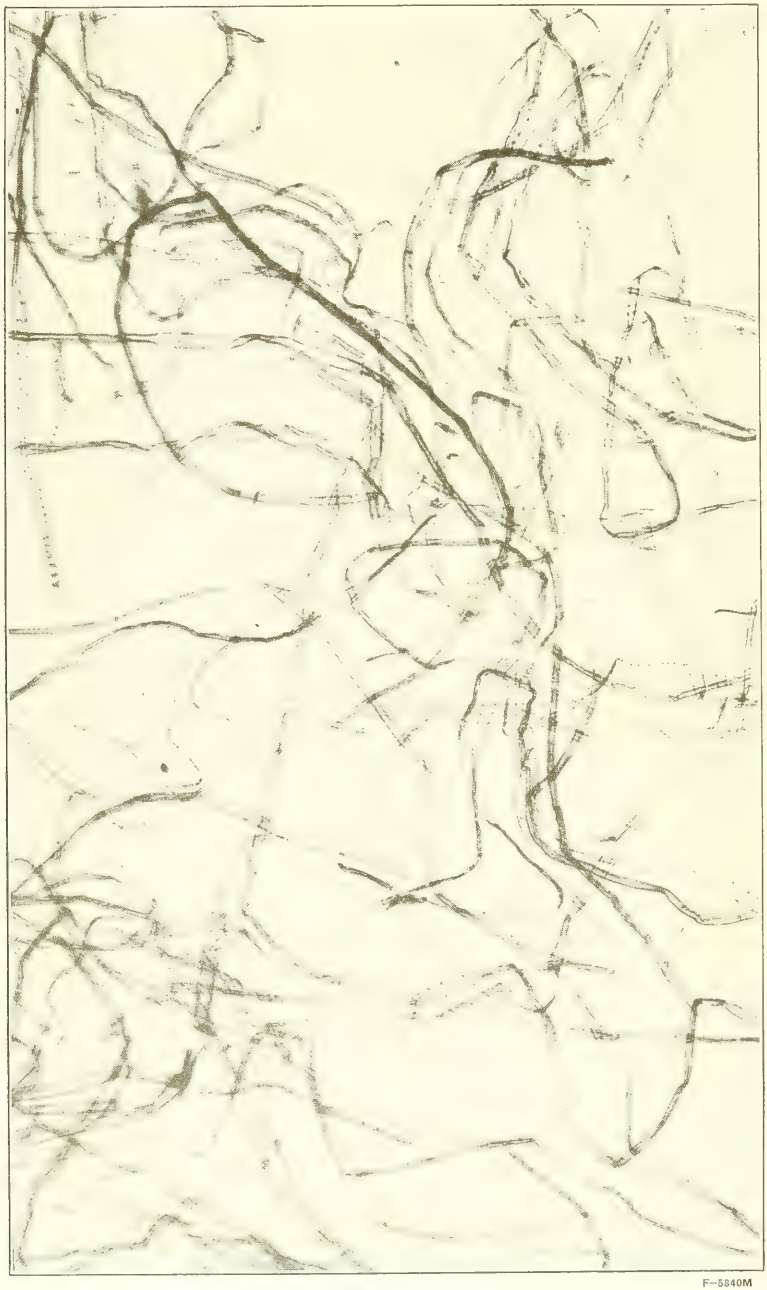
PULP PRODUCED IN COOK 74.



F–5833M

PULP PRODUCED IN COOK 72.



F-5840M

PULP PRODUCED IN COOK 71.

TABLE 3.—*Cooking conditions and results.*

VARYING AMOUNT OF COMBINED SO_2.

Cook No.	Maximum temperature.	Time to reach 100° C.	Time to reach maximum temperature.	Bone-dry chips used.	Gallons acid.	Total SO_2.	Free SO_2.	Combined SO_2.	Ratio F/C.	Duration of cook.	Yields—bone-dry basis.			Bleach consumption.	Tintometer readings.				Strength tests.						
											Yield of unscreened pulp.	Screenings.	Yield of screened pulp.		Red.	Green.	Blue.	Black.	Weight per ream	Mullen test.	Strength ratio per pound.	Strength factor per 0.001-inch thickness.	Breaking length average.	Stretch average.	Folds average.
	° C.	Hrs.	Hrs.	Lbs.		P. ct.	P. ct.	P. ct.		Hrs.	P. ct.	P. ct.	P. ct.	P. ct.	Parts.	Parts.	Parts.	Parts.	Lbs.	Points.	Points.	Points.	Mtrs.	P. ct.	
99	133	2	3	74.2	63	4.98	4.74	.30	19.7	4.72	60.40				44	33	28	195							
98	133	2	3	74.2	63	4.99	4.49	.50	8.99	4.92	[1] 55.20														
75	135	2	3	74.2	63	5.02	4.40	.62	7.1	5.25	46.21	3.05	43.16	50	58	45	40	157	54.0	43.0	0.80	1.03	6,975	2.31	180
67	135	2	3	74.2	63	5.02	4.35	.67	6.49	5.33	46.29	2.17	44.12	40	66	54	48	132	43.5	37.5	.86	1.08	7,350	1.86	277
74	135	2	3	74.2	63	5.01	4.20	.81	5.18	5.50	45.33	1.45	43.88	20	66	55	51	128	44.5	37.0	.83	1.02	7,975	2.12	147
72	135	2	3	74.2	63	5.06	4.04	1.02	3.96	6.50	45.03	.98	44.05	13	72	64	59	105	51.0	46.4	.91	1.16	7,500	2.22	262
79	135	2	3	74.2	63	5.00	3.72	1.28	2.90	6.95	45.07	.80	44.27	12	72	66	61	101	43.5	36.9	.85	1.10	7,345	3.00	421
70	135	2	3	74.2	63	5.06	3.53	1.53	2.31	7.07	45.37	.75	44.62	12	75	66	64	95	45.0	40.8	.91	1.25	7,838	2.32	356
71	135	2	3	74.2	63	5.04	2.95	2.09	1.41	7.75	45.80	.81	44.99	12	73	66	62	99	42.5	37.6	.88	1.14	8,030	2.25	282
VARYING TOTAL SO_2.																									
81[3]	135	2	3	74.2	63	6.98	5.59	1.39	4.01	6.00	45.32	1.01	44.31	10	74	67	63	96	39.5	34.3	0.84	1.05	7,115	2.71	319
86	135	2	3	74.2	63	6.00	4.80	1.20	4.00	6.35	45.06	1.04	44.02	14	71	64	60	105	41.5	32.1	.77	1.01	6,135	2.97	247
87	135	2	3	74.2	63	5.04	4.03	1.01	3.99	6.73	45.17	.96	44.21	14	74	65	61	100	46.5	37.5	.81	1.05	5,895	2.85	376
88	135	2	3	74.2	63	3.99	3.19	.80	3.99	7.08	46.67	1.37	45.30	18	67	57	54	122	44.5	34.3	.77	1.01	6,195	2.56	424
89	135	2	3	74.2	63	3.02	2.41	.61	3.95	7.42	47.45	3.80	43.65	45	60	48	41	151	50.0	42.1	.84	1.09	6,245	2.68	466
VARYING TEMPERATURE.																									
90	148	2	3	74.2	63	5.03	4.03	1.00	4.03	5.02	45.42	1.84	43.58	22	67	56	52	125	43.5	29.1	0.67	0.88	5,510	2.69	163
91	140	2	3	74.2	63	5.02	4.02	1.00	4.02	6.00	45.70	1.32	44.38	19	68	57	53	122	45.5	38.2	.84	1.08	5,965	3.12	733
92	130	2	3	74.2	63	5.04	4.02	1.02	3.94	8.17	46.15	1.24	44.91	14	72	61	55	112	53.0	47.5	.90	1.21	6,480	3.20	1,077
94	120	2	3	74.2	63	5.03	4.02	1.01	3.98	11.97	46.59	1.15	45.44	12	69	60	56	115	51.0	46.0	.90	1.22	6,390	3.39	1,174
97	115	2	3	74.2	63	5.04	4.03	1.01	3.99	14.72	47.10	.88	46.22	13	66	56	51	127	52.0	50.8	.98	1.28	6,430	4.00	1,565
100	110	2	3	74.2	63	5.03	4.02	1.01	3.98	24.75	49.00	.67	48.33	11	64	55	49	132	43.0	39.0	.91	1.22	6,645	3.33	995

[1] Pulp from this cook was given severe beater treatment to open up the chips present. [2] Pulp discarded. [3] Bad leak developed in third hour of this cook.

EFFECT OF VARYING TOTAL SULPHUR DIOXIDE.

Cooks were made varying the amount of total SO_2 from 3.02 to 6.98 per cent, but in each case the ratio of free to combined SO_2 was kept at 4 to 1 and the temperature at 135° C. Figure 9 gives the curves

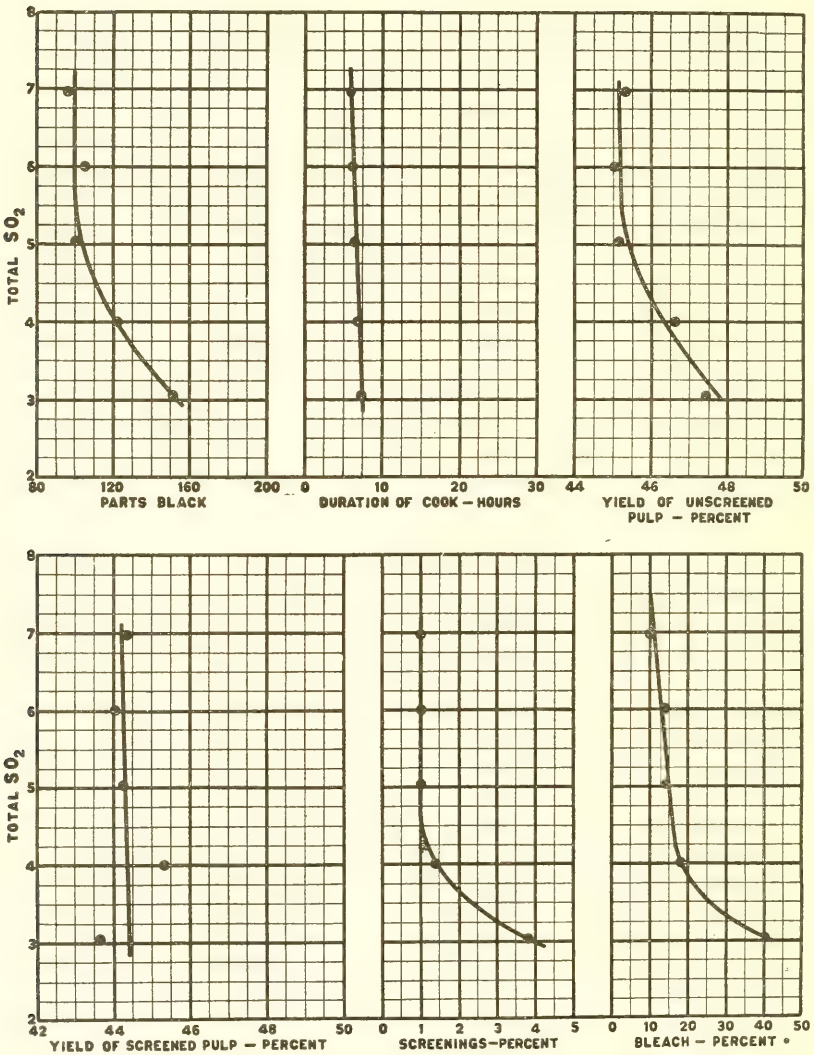


FIG. 9.—Effect of varying the amount of total SO_2 in the cooking liquor.

showing the effect on the different factors studied, parts black, duration of cook, yields, and bleach consumed. While these cooks were made with the ratio of free to combined SO_2 of 4 to 1, the actual amount of combined sulphur dioxide in the cooking liquor decreased with the total, as shown in Table 3.

The curve for parts black shows that after a total of 5 per cent is reached, any increase in the total SO_2 does not produce a lighter pulp, but below that point there is a rapid darkening. An increase in the total SO_2 causes a shortening in the cooking time, as would be expected. The yield of unscreened pulp and screenings shows a decrease as the total SO_2 is increased, which becomes only slight as a total SO_2 of 5 per cent is reached. The yield of screened pulp remains practically constant, because even if the amount of unscreened pulp is increased as the total SO_2 is decreased, the amount of screenings increases in almost the same amount. An increase in the total SO_2 causes a decrease in the amount of bleaching powder necessary to bleach the pulp to a standard white. Below 4 per cent there is a rapid increase, while above that point there is a gradual decrease in the bleaching powder necessary. The strength tests in this series as in the previous one, were unfortunately very irregular and no conclusions could be arrived at from them.

A study of the curves shows that below 5 per cent total SO_2 there is a decided effect on some of the factors studied. At 5 per cent total SO_2 the liquor had a combined SO_2 of 1.01 per cent; and at the 4 and 5 per cent total SO_2, a combined SO_2 of 0.80 and 0.61 per cent, showing again that as we go below 1 per cent in combined sulphur dioxide, the parts black, the amount of screenings, and the bleach consumed rapidly increase, for the reason that there is less cooking action.

Photomicrographs of the pulps obtained in cooks 81, 86, 87, and 89 are shown on Plates V, VI, VII, and VIII. Cook 81, which was made with a high total SO_2, is more thoroughly cooked than cook 89, which was made with a low total. The latter contains much lignified fiber, the result of having the low percentage of lime in the liquor.

EFFECT OF VARYING THE TEMPERATURE OF COOKING.

To study the effect of variations in temperature, cooks were made using an acid of the same composition in each case, but varying the temperature from 110° to 146° C. Figure 10 shows the effect on parts black or color of the pulp, on duration of cook, on yields of pulp and screenings, and on amount of bleaching powder necessary to bleach the pulp to a standard white.

Varying the temperature has little or no effect on the color of pulp produced. The duration of cooking rapidly increases as the temperature is lowered, and apparently there would be very little cooking action under 110° C. At 146° C. the cook finished in a little over 5 hours, while at 110° it took almost 25 hours. The yields of screended and unscreened pulp both increase as the temperature is lowered, especially between 120° and 110°, where there is an increase of almost 3 per cent. In the other 10-degree periods the increase amounts to

only about 0.5 per cent. This probably is due to a decrease in the amount of hydrolysis of the cellulose occurring under 120° C. The screenings decreased with the temperature. The explanation for this is that with the higher temperature the cooks are finished before the

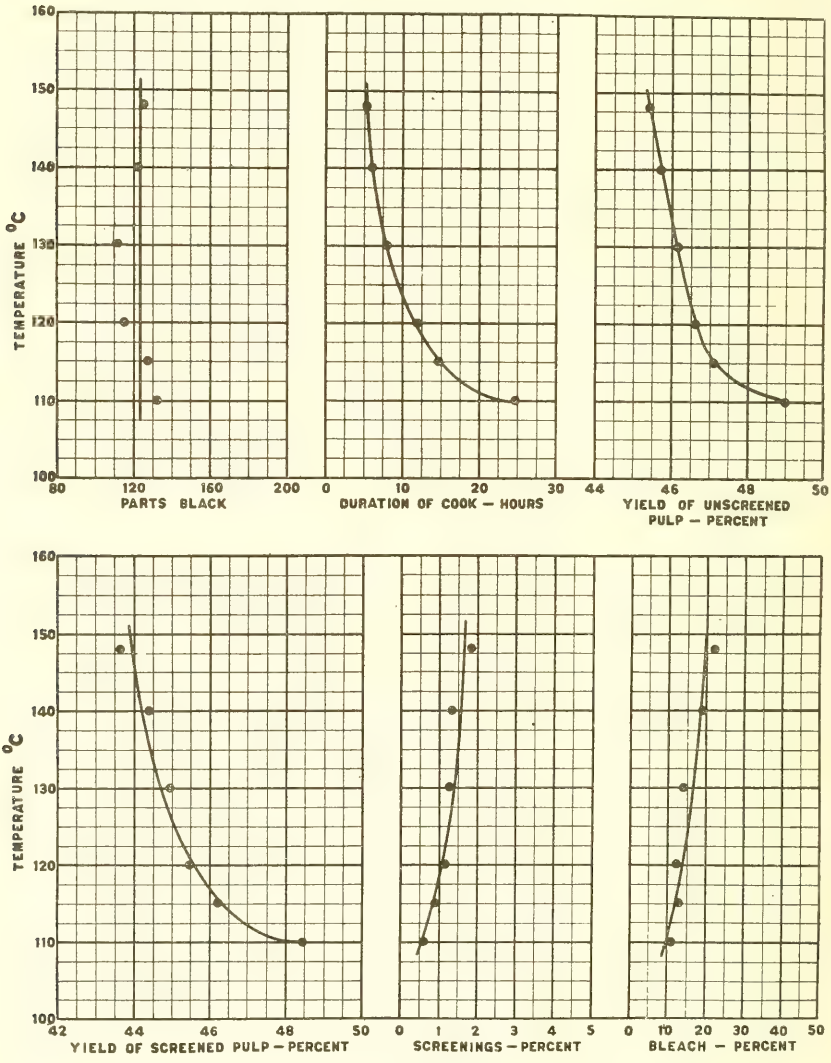
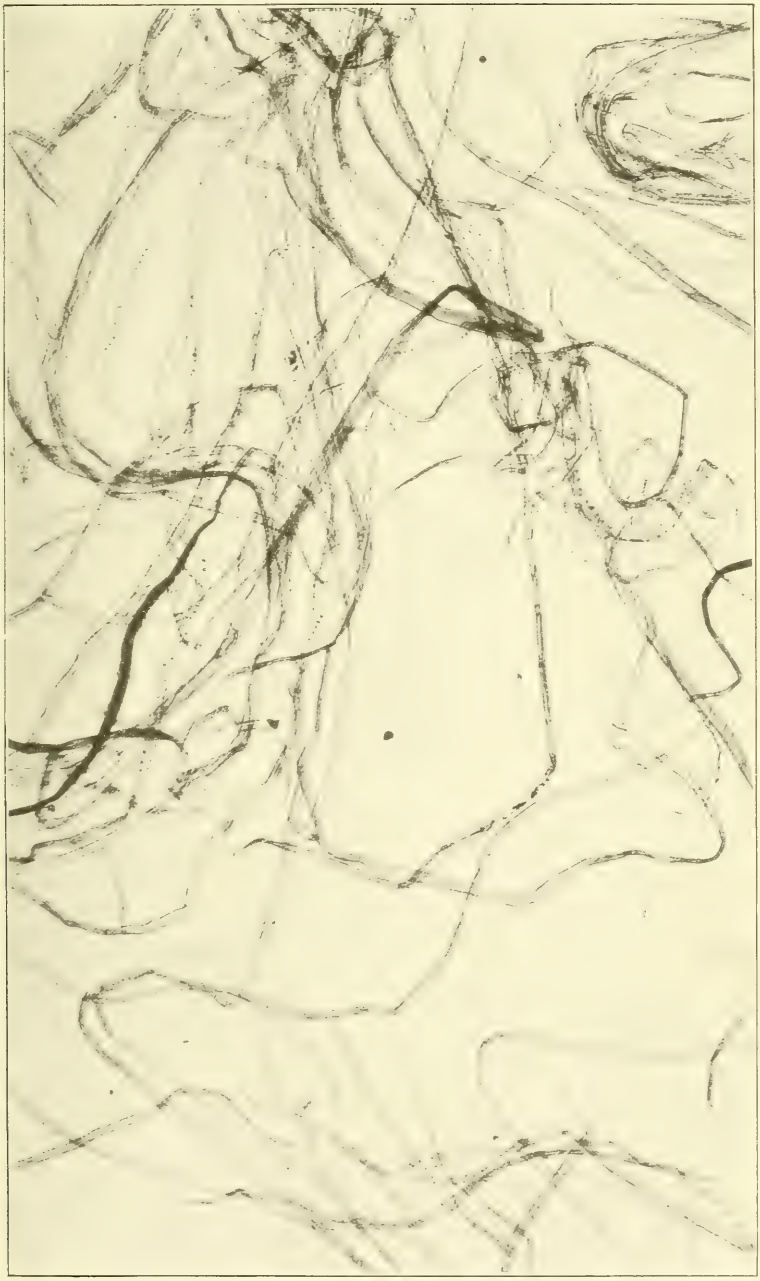


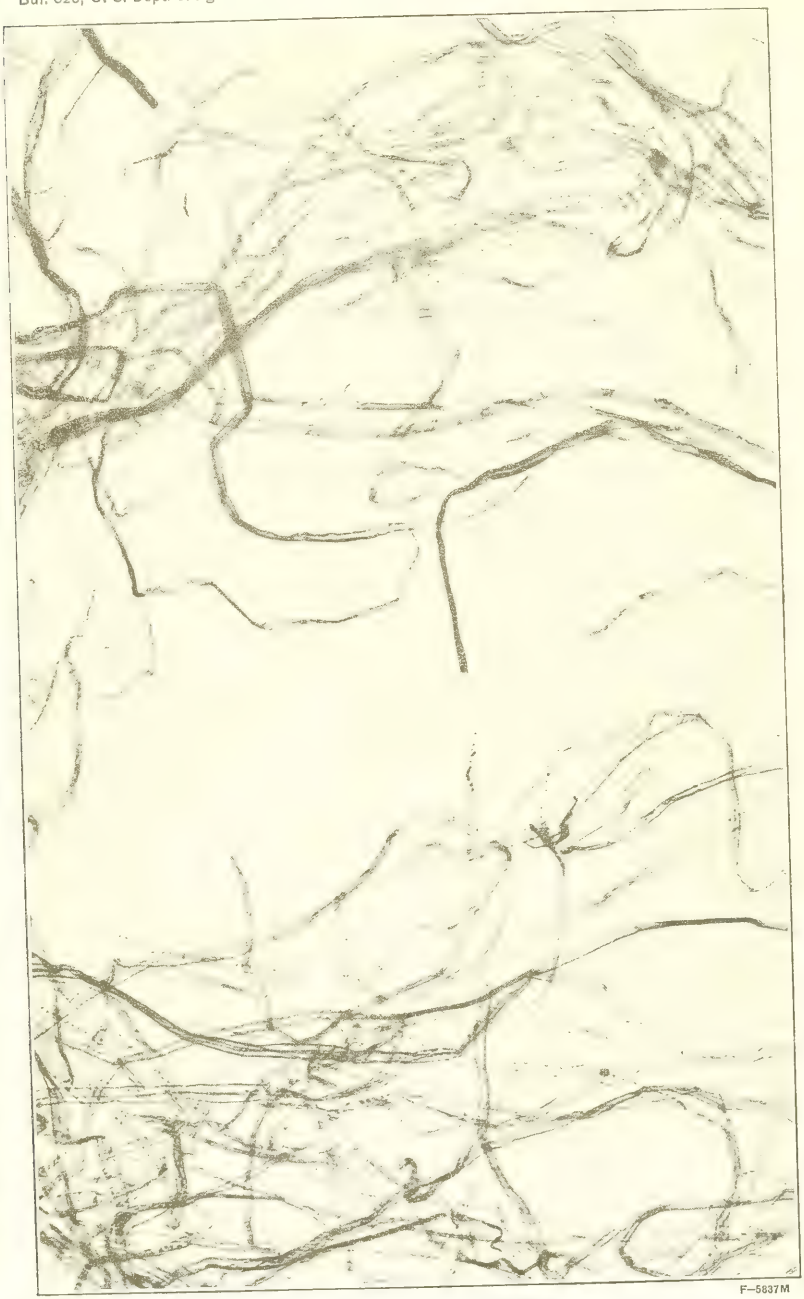
FIG. 10.—Effect of varying the temperature of cooking.

inner portions of some of the larger chips are thoroughly cooked, while the smaller ones are probably overcooked. The lower temperatures with their longer cooks insure a more even cooking and therefore produce less screenings. Decrease in the temperature produced a



F-5335M

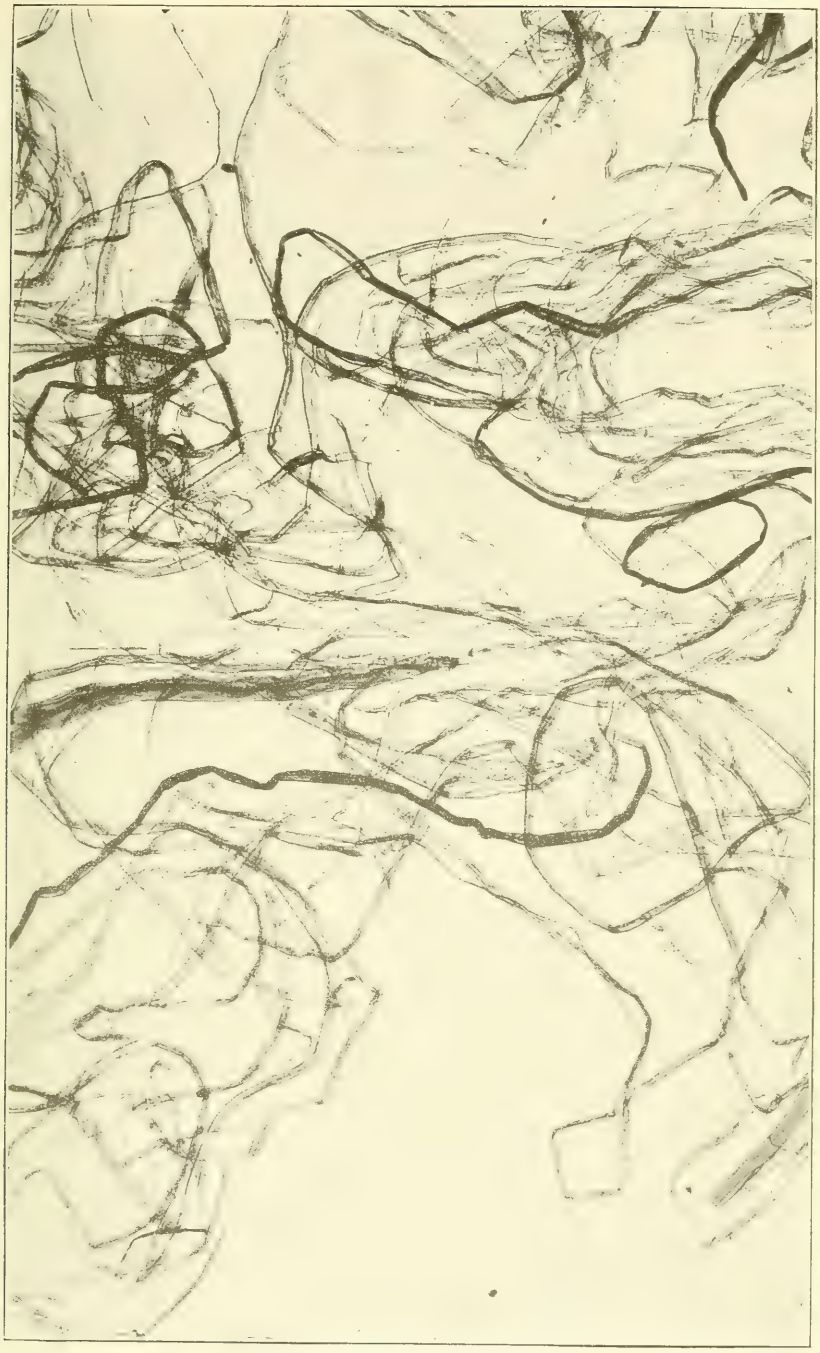
PULP PRODUCED IN COOK 81.



PULP PRODUCED IN COOK 86.

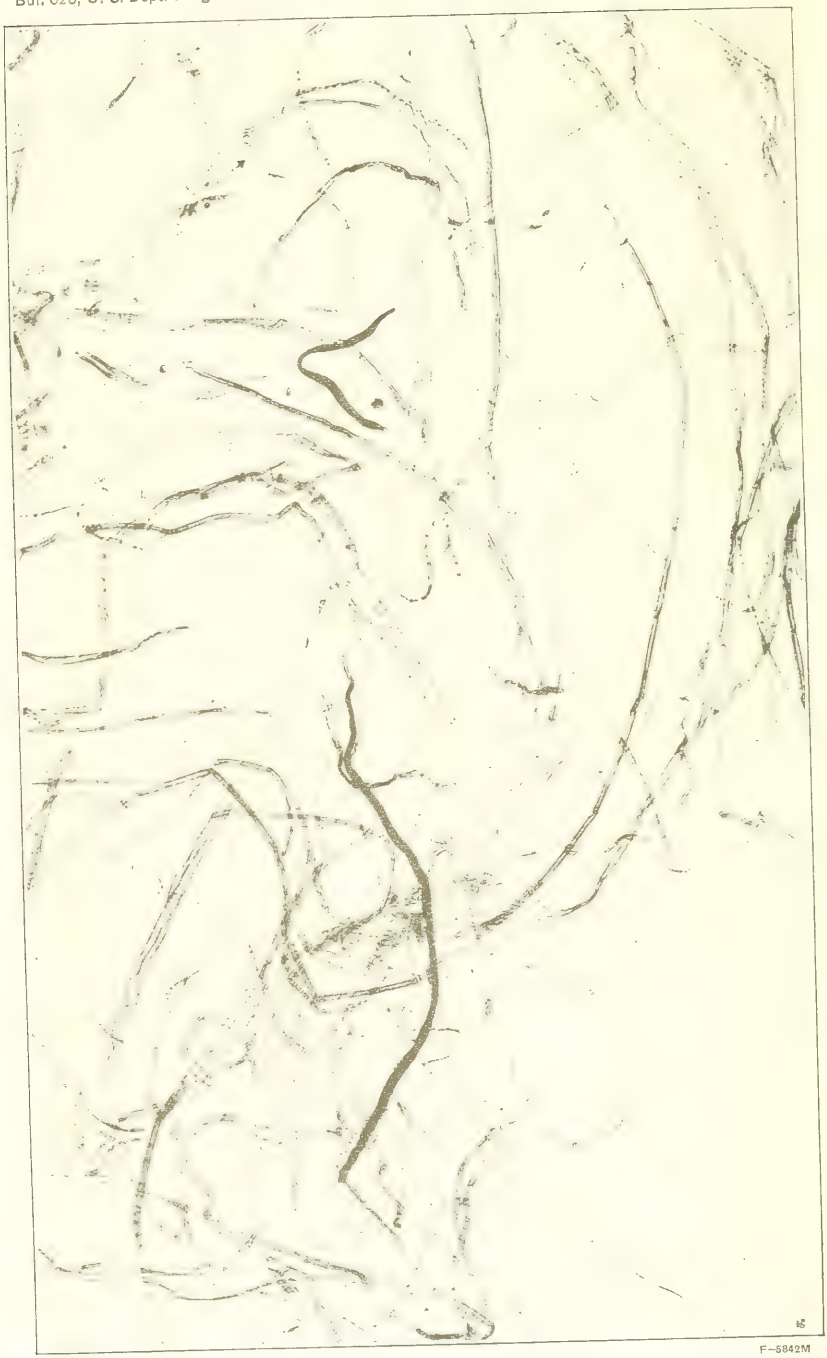
PULP PRODUCED IN COOK 87.

PULP PRODUCED IN COOK 89.



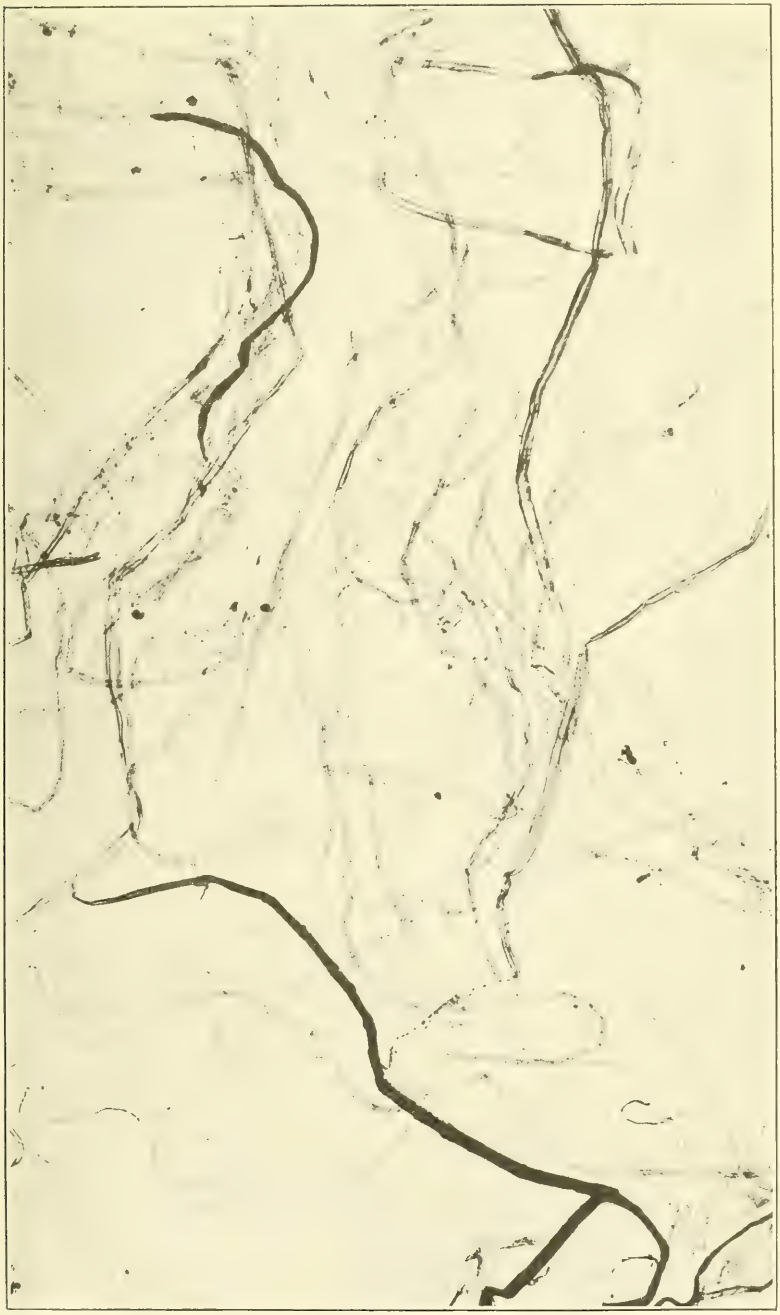
F–5832M

PULP PRODUCED IN COOK 90.



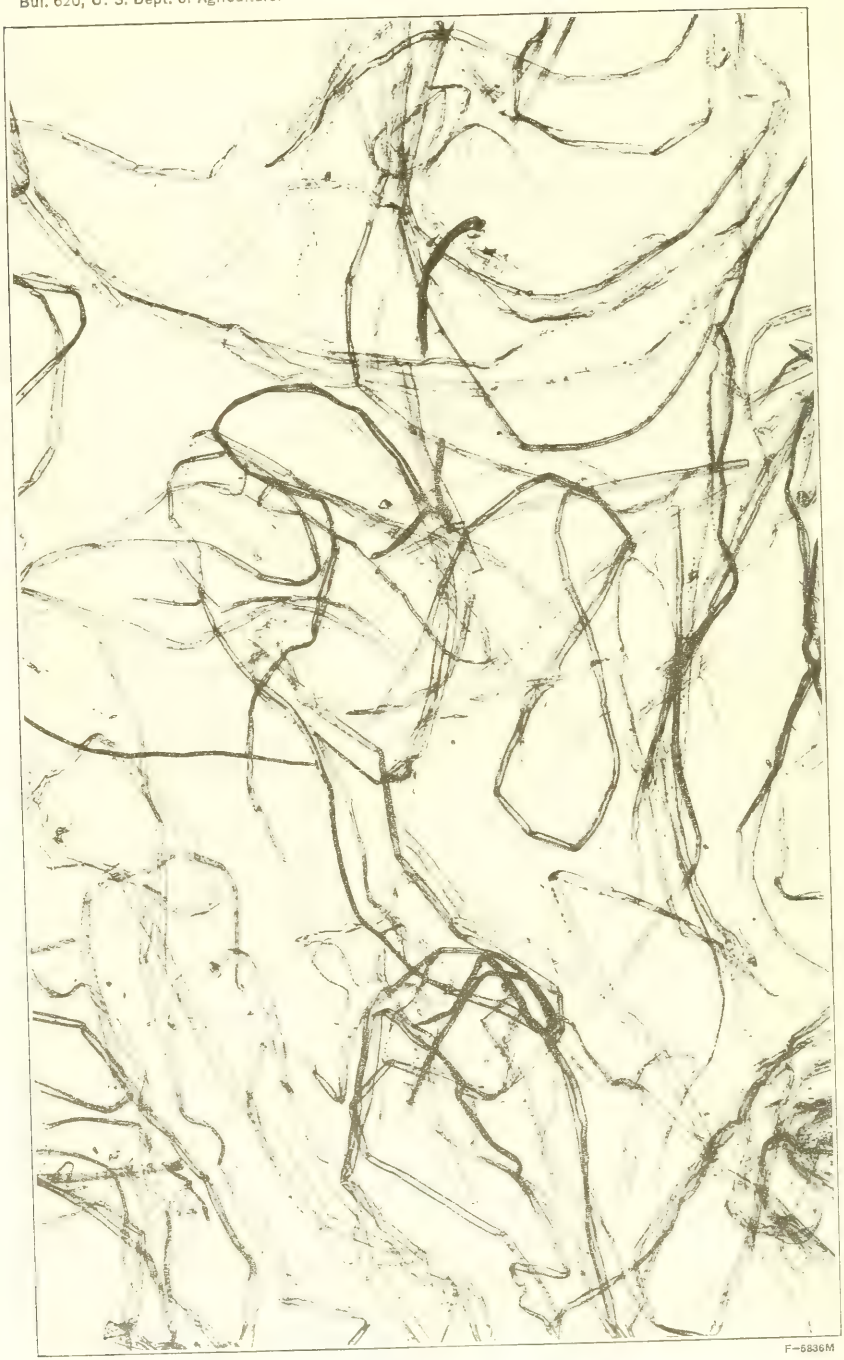
F–5842M

PULP PRODUCED IN COOK 92.



F—5830M

PULP PRODUCED IN COOK 97.



PULP PRODUCED IN COOK 100.

decrease in the amount of bleach consumed, as indicated by the curve. This is rather surprising when one considers that the yield of screened pulp increased almost 5 per cent, while the bleach decreased from 22 to 11 per cent. This must be due to the more uniform cooking occurring at the lower temperatures so that broken up, uncooked shives did not consume bleach. The values for strength are fairly regular (Table 3), probably as a result of the use of an improved style of beater in this series. As would be expected, they show an increase in strength with decrease in temperature.

Photomicrographs of the pulps produced in cooks 90, 92, 97, and 100 are shown on Plates IX, X, XI, and XII. Cook 90, which was made with a high temperature, contains much lignified fiber and is not very uniform; while cook 100, which was made at a low temperature, seems to be well cooked and has fibers nearly all of the same length.

SUMMARY OF RESULTS.

1. These experiments have demonstrated that a standard color can be used with which to match the color of the liquor in the digester to determine when a cook is finished. A cook can be duplicated at any time by comparison with this standard.

2. The limit to which the combined SO_2 can be decreased to obtain good cooking seems to be about 1 per cent. Below this there is a rapid darkening of the pulp produced, and an increase in the screenings and bleach consumed.

3. When the temperature and total SO_2 are kept constant, the yield of screened pulp increases somewhat with increase in the combined SO_2, because of the more thorough cooking. Consequently, less screenings are obtained.

4. When the temperature and total SO_2 are kept constant, a decrease in the amount of combined SO_2 causes quicker cooking action, so that a cook can be finished in less time.

5. An increase in the total SO_2 causes a decrease in the cooking period, other factors remaining constant.

6. The screenings and color of the pulp remain constant as the total SO_2 is decreased to about 5 per cent, after which there is a rapid increase in both of these factors.

7. The higher the total SO_2, the easier it is to bleach the pulp, other factors being the same.

8. The amount of screenings decreases as the temperature is lowered, because of the more even cooking obtained at the lower temperatures.

9. The bleach is reduced as the temperature is decreased, while the yield of pulp increases.

METHODS OF ANALYSIS AND OTHER TESTS.

BONE-DRY WEIGHT.

The bone-dry weight was determined by taking a sample of the wood, pulp, or screenings and drying to constant weight in an oven at 104° C. The ratio of the weight after drying to that before drying then became the factor by which the bone-dry weight of the entire amount was calculated. All yields and similar calculations are made on the basis of bone-dry weight.

COLOR.

The color of the pulp was determined by means of the Ives tint photometer. By means of this apparatus the color of the paper is reduced into parts of the three primary colors, red, green, and blue. When these three add up to 300, as in the case of the magnesia standard used for comparison, then pure white is obtained. The sum of the three primary colors subtracted from 300 gives the "parts black" of the paper in question and is a measure of its color, the higher the parts black, the darker the pulp.

BLEACH REQUIRED.

The bleaching solution was made by mixing bleaching powder with water, allowing the sediment to settle and drawing off the clear solution. Its strength was determined by titrating 10 cc with $\frac{0.987N}{10}$ solution of sodium arsenite using starch iodide paper as an outside indicator. The number of cubic centimeters necessary to complete the titration gives the gram per liter of 35 per cent bleach. Twenty-five grams (bone-dry) of the pulp were put in enameled jars with 2,000 cc of water and thoroughly mixed. The calculated amount of bleach liquor was then added and jars placed in a water bath heated with an electric coil which kept it a temperature of 110° F. The contents of the jar were kept in motion by means of a stirring apparatus until all the bleach was exhausted. The pulp was then thoroughly washed, made into hand sheets, and its color compared with a standard to which the addition of more bleach would not make it any whiter. The per cent of bleach necessary to give a standard white is expressed in per cent of the bone-dry weight of the pulp.

ANALYSIS OF COOKING LIQUOR.

PREPARATION OF $\frac{N}{16}$ IODINE.

The iodine solution is made by diluting from a concentrated solution. This was made by dissolving 156.7 grams of iodine and 217 grams of potassium iodide in about 250 cc of water and diluting to 1

liter. Two hundred cc of this solution make 4 liters of approximately $\frac{N}{16}$ iodine. This is then standardized against $\frac{N}{16}$ sodium thiosulphate solution.

PREPARATION OF $\frac{N}{16}$ SODIUM THIOSULPHATE.

Weigh out 24.7 grams of sodium thiosulphate, dissolve in water, and dilute to 1,000 cc. This is standardized according to any of the standard methods.

DETERMINATION OF TOTAL SO_2.

A 300 cc Erlenmeyer flask is filled with about 150 cc distilled water and enough $\frac{N}{16}$ iodine solution added so that only about 2 cc of the iodine solution will complete the titration. Two cc of the liquor to be analyzed are then added to this and the titration completed, using starch solution as an indicator. This gives the total SO_2 present and every cc on the burette reads to one-tenth of 1 per cent.

DETERMINATION OF FREE SO_2.

A 300 cc Erlenmeyer flask is filled with about 150 cc of distilled water and enough $\frac{N}{16}$ sodium hydrate added so that only about 2 cc will complete the titration. Two cc of the liquor to be analyzed are then added and the titration completed using phenolpthalein as an indicator. Each cubic centimeter is equal to one-tenth of 1 per cent of free SO_2. The difference between the free and total gives the SO_2 present combined with lime, and multiplying the amount of combined SO_2 by 0.875 gives the amount of lime (CaO) in combination.

PUBLICATIONS ON PULP AND PAPER.

Paper Pulp from Various Woods. Forest Service Bulletin (unnumbered), by Henry E. Surface. (Out of print.)

Experiments with Jack Pine and Hemlock for Mechanical Pulp. Forest Service Bulletin (unnumbered), by J. H. Thickens. (Out of print.)

*Bibliography of the Pulp and Paper Industries. Forest Service Bulletin 123, by Henry E. Surface. Price 10 cents.

*The Grinding of Spruce for Mechanical Pulp. Forest Service Bulletin 127, by J. H. Thickens. Price 15 cents.

*Suitability of Longleaf Pine for Paper Pulp. Department of Agriculture Bulletin 72, by Henry E. Surface and Robert E. Cooper. Price 5 cents.

*Effects of Varying Certain Cooking Conditions in Producing Soda Pulp from Aspen. Department of Agriculture, Bulletin 80, by Henry E. Surface. Price 15 cents.

*Ground Wood Pulp. Part I, Grinding of Cooked and Uncooked Spruce; Part 2, Substitutes for Spruce in the Manufacture of Ground Wood Pulp. Department of Agriculture Bulletin 343, by J. H. Thickens and G. C. McNaughton. Price 5[t] cents.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 621

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E. W. NELSON, Chief

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THE CROW AND ITS RELATION TO MAN.

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INTRODUCTION.

Since the publication in 1895 of "The Common Crow of the United States"[1] no comprehensive treatise on the economic status of the crow has appeared. The edition of that bulletin has long since been exhausted, and the only recent publications available for inquirers have been short articles on the crow appearing in papers dealing with a number of birds.[2] In response to the many urgent requests for information for a number of years a complete investigation of the food habits of the crow was undertaken, and this paper is the result. As the former bulletin was based on an examination of the food of only 909 crows, collected mainly in eastern States, it was apparent that the number would have to be supplemented by material from other

[1] Barrows, W. B., and Schwarz, E. A., Bull. No. 6, Div. of Ornithology and Mammalogy, U. S. Dept. Agr., 1895.

[2] Notably Farmers' Bulletins 54, pp. 15–17, 1897 (revised edition pp. 22–23, 1904); 630, pp. 17–19, 1915; and 755, pp. 17–19, 1916.

NOTE.—This bulletin discusses in detail the beneficial and harmful food habits of the crow; gives a general account of its life history and geographic distribution; and shows how it may be controlled where necessary. It is for general distribution.

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parts, especially the Middle West, before fair judgment could be passed. A campaign with this object in view was inaugurated, with the result that 2,118 stomachs of crows, both old and young, became available for this investigation. Effort was made also, by means of over 3,000 letters of inquiry, to secure reliable information as to the good or harm done by the crow, based on actual field observation. The data obtained have made it possible to present considerable trustworthy testimony which distinctly reflects present conditions. The quantity and character of the combined evidence thus secured seems sufficient to justify a final conclusion as to the economic status of the crow in this country.[1]

It is doubtful whether a study of the food habits of any other North American bird involves as many intricate problems as that of the crow. Practically omnivorous, the bird is capable of surviving in widely diversified environments. In its diet may be found everything from the choicest poultry and the tenderest shoots of sprouting grain to carrion and weed seeds, many of which at best offer but a morsel of nourishment. The fact that no less than 656 specifically different items have been identified in the stomachs examined gives some idea of the bird's resourcefulness, its potentialities for good or harm, and the complexity of the problem of determining its worth. Popular opinion also, often based on years of intimate experience, is by no means uniform. Many complaints against the bird are wellnigh traditional, while some of its beneficial habits have been matters of common knowledge for generations. Thus irreconcilable differences of opinion may exist among residents of even the same community. And by no means of one mind are those persons who have studied the bird from a strictly scientific standpoint. The writer, however, feels that the abundant evidence before him has been carefully and impartially weighed and asks indulgence of those who may discover that the process of reasoning from these data is at variance with their own.

SYSTEMATIC POSITION AND DISTRIBUTION OF THE CROW.

Notwithstanding the fact that to the average farmer in eastern United States the crow (Pl. I) is the most familiar of birds, and one would hardly suppose that there could be any ambiguity in the use of

[1] Much of the information and material upon which this bulletin is based was acquired through the kind assistance of persons who volunteered their services. As they are too numerous to mention individually, the writer is compelled to express his appreciation for their help collectively. Without their aid very little information would have been available on the extent of damage to crops and the efficiency of protective measures. Further, without the assistance of specialists in various fields, to whom also the writer is greatly indebted, many problems arising in the examination of stomachs would have remained unsolved.

the term "crow," there is considerable uncertainty as to identification in regions where the bird is scarce or where its range overlaps that of closely related species. Ordinarily little distinction is made by residents of the South Atlantic coast between the common crow and the fish crow, a bird of quite different habits; and similar confusion exists among nonornithologists of the northwestern coast, where the other maritime form, the northwestern crow, mingles with the common species. In the Southwest the small white-necked raven frequently passes under the appellation of crow, and in some other parts of the West even the larger ravens have been misnamed.

Inasmuch as it is contemplated eventually to issue reports on the economic status of all members of the genus *Corvus*, which includes both crows and ravens, it seems well to define clearly the systematic position and range of the common crow, the one of which this bulletin treats. Eleven subspecifically different forms of the genus *Corvus* have been recorded from North America and Greenland. The ranges of nine of these come within the borders of the United States. The other two forms are the rook (*Corvus frugilegus* Linnæus) and the hooded crow (*Corvus cornix* Linnæus), both of which have occurred in Greenland. Of the ravens three are found in the United States. The northern raven (*Corvus corax principalis* Ridgway), a more or less arctic race, occurs along the northern border and at the higher altitudes, while the common raven (*C. c. sinuatus* Wagler) is a more abundant form in the Western States. The white-necked raven (*C. cryptoleucus* Couch) occupies part of the southwestern desert regions. By far the most numerous species of this genus in the United States is the common crow (*Corvus brachyrhynchos brachyrhynchos* Brehm), which, with the three closely related subspecies, the Florida crow (*C. b. pascuus* Coues), the southern crow (*C. b. paulus* Howell),[1] and the western crow (*C. b. hesperis* Ridgway), gives practically a transcontinental range to the species. *Corvus b. brachyrhynchos* Brehm extends its breeding range northward nearly to the mouth of the Mackenzie River, northern Manitoba, central Quebec, and Newfoundland. It may be found from the Atlantic coast westward to Montana, Wyoming, central Nebraska, Kansas, and Texas. The limit of its range on the west, however, can not be stated satisfactorily, as in the western part of the Plains the crow is merely a rare and erratic breeder. The western crow (*C. b. hesperis* Ridgway) is found in the Pacific Coast States and eastward to eastern British Columbia, Montana, and Texas. The southern crow (*C. b. paulus* Howell) has a range extending throughout the Gulf States east of central Texas and northward as far as the

[1] Proc. Biol. Soc., Washington, XXVI, pp. 199–202, Oct. 23, 1913.

District of Columbia and southern Illinois. The Florida crow (*C. b. pascuus* Coues) has a limited range throughout peninsular Florida. The two remaining species of the genus *Corvus* are the maritime forms, the fish crow (*Corvus ossifragus* Wilson) and the northwestern crow (*Corvus caurinus* Baird). The former is restricted to the Atlantic seacoast from Long Island south to Florida and westward along the Gulf coast to Texas; while the latter occupies the northwest coastal region from Puget Sound to southern Alaska.

In this bulletin the name "crow" has been used to cover the four subspecifically different forms recognized under *Corvus brachyrhynchos*. The food habits of these subspecies are essentially the same, varying only to the extent naturally occasioned by the varying character of the food supply in the different parts of an area as great as that covered by their combined ranges. In some of the Western States where the crow appears only as an occasional breeder it has but little economic significance. Among such areas may be mentioned all of Nevada, the greater parts of Arizona, New Mexico, Colorado, Wyoming, Utah, and Idaho, and eastern Washington and Oregon. The bird is only locally abundant in California. The western parts of Texas, Oklahoma, Kansas, and Nebraska support very few crows, while Montana, North Dakota, and South Dakota, as well as the Gulf States of Florida, Alabama, Mississippi, and Louisiana, embrace large areas where crows are not common.

A consideration of the economic value of the crow in the United States, judging from the average yearly abundance, may therefore be confined principally to the States along the Atlantic slope of the Appalachians and those in the central and upper Mississippi Valley. In the former area the States south of Virginia are less abundantly supplied with these birds during the breeding season than those to the north, while in winter the States of North Dakota, South Dakota, Minnesota, and the northern parts of Wisconsin, Michigan, and Maine harbor but few.

LIFE HISTORY.

A brief statement of the life history of the crow is necessary if its varied activities at different seasons of the year are to be appreciated and if the significance of its change of food habits from month to month is to be understood. A clear understanding of the breeding habits of the crow is essential also to a correct interpretation of the food habits of the young; and scarcely less important in this connection is the problem of the bird's migration and roosting habits in the colder months, when the normal crow population of certain sections is swelled manyfold by countless hordes from the north.

In presenting part of this information the writer can do no better than quote from Bendire:[1]

Nest building in the more southern States begins sometimes by February 20, and correspondingly later northward. In the vicinity of Washington, District of Columbia, fresh eggs may be occasionally found in the last week in March, but more frequently during the first two weeks in April. Along our northern border they nest generally about the beginning of May; and even in the most northern portions of their range they have been known to breed equally early, but most frequently nidification here is protracted well into June. In Idaho, Washington, and Oregon it is at its height between April 15 and May 20. The nests are bulky, usually well constructed, and placed in the forks of branches, generally well up and hard to reach. Occasionally one is placed near the main trunk, this being mostly the case where bushy cedars or junipers are used. Any sort of tree may be chosen for a nesting site, providing it is one of dense foliage, which will hide the nest well. In some localities pine trees seem to be preferred, while in others oaks are often selected. In the West cottonwoods, junipers, and willows are most frequently used. Nests are usually placed at heights varying from 20 to 60 feet; but I have found some barely 6 feet from the ground, and in many localities in the West they are rarely placed over 20 feet up. Here also they are said to occasionally nest on the ground, but I have never observed this personally. Crows rarely nest in deep forests, the borders of woods and the river bottoms being preferred for such purposes. The nests are composed outwardly of sticks, weed stalks, corn husks, and other coarse material, and lined with grapevine bark, fine roots, dry grass, leaves, straw, moss, rags, wool, and hair, the lining varying in different localities. Where cattle are plenty the nests are often found lined with more or less of their hair. These finer materials are well quilted together. The outer diameter of the nest is usually about 24 inches by 9 inches in depth. The inner cup is from 4 to 6 inches deep and from 12 to 15 inches in diameter. This prevents the eggs from being thrown out of the nest during high winds when placed in slender branches in the extreme tops of trees.

The number of eggs to a set varies from four to eight. Sets of five are most commonly found, while those of seven are rare, and those of eight quite unusual. Mr. A. C. Kempton, Wolfville, Nova Scotia, writes me that he found a set of ten eggs in the spring of 1890, which he believes were laid by the same bird. In the Western States usually from three to five eggs constitute a set, and those of six, according to my observations, are much rarer than in the East. Incubation lasts about eighteen days, and both parents assist in this duty. The young are born blind and naked, and remain in the nest about three weeks. While crows steal many of the eggs of other birds, they apparently do not molest any of their own kind, but if several pairs nest close together they will steal nesting material from each other whenever an opportunity occurs. The old nests are resorted to for several seasons in succession where not molested. Only one brood is raised in a season; if the first eggs are taken, they usually lay a second set, but rarely in the same nest. When the young are nearly fledged, they may often be seen sitting on the rim of the nest or on branches close by, watching for the return of the parents with food, and keeping up an incessant clamor.

[1] Bendire, Charles, Life Histories of North American Birds, II, pp. 411–412; Special Bulletin, U. S. Nat. Mus., 1895.

THE ROOSTING HABIT.[1]

While crows, even in the nesting season, are more or less clannish, their gregarious habit is most highly developed during the colder months. Soon after the nesting season one may expect to see evidences of it, but in the latitude of Washington, D. C., roosts are not well established until the end of September. At this time their migratory habits have brought together in a comparatively small area the bulk of the crow population of North America, so that the area lying between the thirty-seventh and forty-second parallels of latitude—that is, from Connecticut to Virginia—and extending westward from the Atlantic coast to beyond the Mississippi River harbors these birds in extremely large numbers. Their roosts are occupied with considerable fluctuation in population until the advent of milder weather in March, when the numbers rapidly decrease.

A variety of situations, differing widely in the character of vegetation, are acceptable as sites for crow roosts. Pine and other evergreens are most frequently chosen, though records of crows passing the night in groves of deciduous trees, as oaks and maples, are common. A large roost in Crawford County, Kans., was in a heavy stand of catalpa. That crows roost among such low vegetation as reeds or tall grass has been noted, while in some cases even in severe weather the birds have been known to gather on the ground in open fields or on exposed sand bars.

Many attempts have been made to estimate the number of birds which gather at some of these roosts, but the daily fluctuation, caused by changes in weather and by birds stopping at some local roost when they have been overtaken by darkness, makes the computing of their number difficult and, in large measure, unsatisfactory. The wide variation of the estimates made by several observers at the same roost readily shows the uncertainty of results. Furthermore, the impression made upon a person not very familiar with the sight of the gathering thousands is quite likely to be an exaggerated one.

A roost at Arlington, Va., was supposed to contain at the height of its occupancy from 150,000 to 200,000 birds. These figures have been averaged from the records of a number of observers and may be regarded as reliable. The "Arbutus" roost, near Baltimore, contained in 1888, according to the account of Mr. C. L. Edwards,[2] a population of more than 200,000. The St. Louis roosts, about 1886, contained from 70,000 to 90,000 crows. One at Peru, Nebr., at the same time had 100,000 to 200,000. Other roosts numbering approximately 200,000 birds were recorded about the same year in New

[1] More fully treated by the author in Winter Crow Roosts: Yearbook for 1915, U. S. Dept. Agr., pp. 83–100 (Sep. 659), 1916.

[2] Edwards, C. L., Amer. Journ. Psychol. I, No. 3, p. 454, May, 1888.

Jersey at Hainesport, Merchantville, Reedy Island in the Delaware River, Bridgeboro, and Centerton; and in Pennsylvania at Davis Grove and Camp Hill. Some of these roosts are still occupied and are said to harbor thousands of birds. A roost at Woodridge, near Langdon, D. C., which appeared to be the successor to that observed some years ago at Arlington, Va., is reported by A. H. Howell, of the Biological Survey, to have harbored 270,000 birds in the winter 1910–11. Mr. Howell estimated that fully 100 crows a second entered the roost at the height of the influx, and added that this would be 6,000 every minute, and if the same rate continued for three-quarters of an hour, which is about the time occupied by the gathering of the clans, 270,000 crows would be established for the night within an area of 5 to 10 acres. He says that while this estimate may be short of the actual number it certainly does not greatly exceed it. Dr. S. D. Judd observed this same roost in February, 1901, when he estimated 100,000 as its population.

A roost located near Chevy Chase, Md., considered to be the successor to the Woodridge roost, and one upon which the writer made observations, gave a much smaller number of birds. Observations made on January 8, 1911, under a line of flight coming from the east, indicated that from 1,800 to 1,900 birds flew past. The four lines of flight entering the roost would probably give a total population of about 7,500. A strong wind was blowing at right angles to the direction of flight, and as this caused the birds to spread out in a pathway fully half a mile wide doubtless many were overlooked. About the 1st of January, 1912, the crows forsook this roosting place, and, again resorting to the previous site near Woodridge, combined with a small number which had been using this place. The writer visited this roost on January 28, 1912, and estimated the number coming from the north at about 6,500. This would mean that the whole roost was occupied by probably from 25,000 to 30,000.

In response to letters of inquiry considerable information bearing on the location, size, and character of crow roosts occupied during the winter of 1911–12 was secured. Upward of 290 correspondents submitted reports of this nature, and while it can not be claimed that the data obtained are anything but a mere fragment of knowledge, the compilation of these facts sheds some light on the location of the winter crow population.

On the map on page 8 (fig. 1) is recorded a total of 170 roosts of varying size. This shows in what areas a rather restricted migratory movement has assembled a large part of the crow population of North America. East of the Appalachians and grouped on the lower watersheds of the Potomac, Susquehanna, Delaware, Hudson, and Connecticut Rivers are many of the most populous roosts, some of

them reported to contain over 100,000 birds. Here the open water maintained by most of these streams throughout the winter and the extensive tidal flats within easy reach of these rendezvous assure the crows a fairly ample supply of food. In the Middle West a greater region of favorable winter habitat has permitted the birds to establish their roosts over a much broader area. As in the East, the winter crows of the Mississippi Valley have selected a district well supplied with their customary winter food. Here the roosts of greatest size are found in southern Indiana, central Illinois, and westward along the Missouri River, while eastern Kansas and northern Oklahoma also support vast numbers. During fall and early

FIG. 1.—Map showing location of crow roosts known to have been occupied in the winter of 1911–12.

spring the northern States from Maine west to the Plains harbor many migrants, which form, at times, temporary roosts of considerable size. From December to the middle of February, however, the birds which frequent these States are comparatively few in number and their roosts seldom contain over a few hundred individuals. The more important of these may be found along the coast of Maine and in west-central New York, in the vicinity of Seneca and Cayuga Lakes. In the South the largest colonies are found along the Atlantic and Gulf coasts and are made up probably of birds resident in the Southern States which have congregated at favorable spots. Fish crows often form the bulk of the population of southern roosts, and in fact are common in colonies as far north as Maryland. On the Pacific coast, owing probably to the milder winter climate, the roosts are found at higher latitudes, the coastal region about Puget Sound being an area particularly well supplied.

Ornithologically, aside from all economic considerations of good or harm arising from the gathering of immense numbers of crows, a winter crow roost must be regarded as one of the most wonderful of bird phenomena still existing in close proximity to large cities. In many instances the lines of flight pass daily over metropolitan districts during the winter months, yet only an extremely small proportion of the people realize their significance. In the immediate vicinity of the roosts the gathering of thousands of birds seldom fails to incite the latent instincts, so frequently present behind the shotgun, to kill for the mere sake of killing, regardless of whether the birds may be doing good or harm. The easy pot shot at hundreds of closely perched birds is a chance that few gunners seem able to resist. But the fact that these birds have maintained this interesting habit, even in the face of constant persecution over a period of many years, bids fair to insure its continuance as long as crows remain abundant.

Economically, the roosting habit is of considerable importance, inasmuch as it results in the gathering of thousands of individuals of a species possessing some harmful traits. Fortunately, the clans do not assemble for the purpose of feeding, but even as it is, large numbers of crows often forage together on comparatively small areas in the vicinity of roosts. Harm is then almost sure to be done to crops still in the field.

INFORMATION FROM CORRESPONDENTS.

While the examination of stomachs affords the most accurate means of determining the various food items that enter into a bird's diet, it frequently fails to give information on certain points essential to a complete consideration of the economic status of a species. This is especially true in the case of the crow. It is impossible in many instances to state with certainty whether the remains of a chicken, wild bird, or small mammal found in a stomach are indicative of the predacious activities of the crow or of its carrion-feeding habits. Neither is it possible to determine accurately what proportion of corn eaten has been stolen from the shock, "pulled" when sprouting, or picked up as waste grain. Financial losses to individual farmers, the efficiency of measures of crop protection and efforts toward the reduction of the number of these birds when found troublesome, and the perplexing complications sometimes arising about game farms and preserves are other important problems which can not be solved in the laboratory.

Fully cognizant of the shortcomings of a method of investigation depending entirely on stomach examination, the writer has relied to a

considerable extent on the field observations of reputable ornithologists and the testimony of reliable farmers, game raisers, sportsmen, and others who have had intimate experience with the crow. For the purpose of securing such information a circular letter, including the following questions on various phases of the economic value of this bird, was prepared:

(1) Are there any crow roosts in your vicinity where the birds congregate in large numbers during the winter months? If so, describe them briefly, noting the approximate number of birds, acreage of the roosts, and characteristic vegetation.

(2) Is the crow numerous in your vicinity during spring and summer?

(3) Does it inflict serious damage upon corn, either when sprouting or when in the shock, and does it appear to be as troublesome in your locality as it was 15 years ago?

(4) Do farmers in your locality resort to the practice of tarring seed corn? If so, how successfully has it protected the crop?

(5) Do crows destroy much poultry and many eggs, and does the habit appear to be confined to a few individuals, or is it a more or less characteristic trait of all crows in your vicinity?

(6) To what extent can the reduction in numbers of our game birds, such as grouse and quail, and many smaller insectivorous species, be attributed to the crow?

(7) Has there been a bounty system on crows in force in your vicinity in recent years? If so, has it noticeably reduced the numbers of this bird?

Nearly 3,000 copies were mailed, the bulk on December 21, 1911. Since then numerous additional circulars have been distributed. Replies to the number of 909 were received, and much of the information thus obtained has been incorporated in this bulletin.

FOOD HABITS.

What the crow eats or does not eat is the first question to be answered in an inquiry into its economic status. To determine with accuracy the various food items entering into the diet, experience has shown no method more reliable than the microscopic examination of stomach contents, carefully conducted with the aid of extensive reference collections for comparison. Such a method of investigation, supplemented when necessary by field observation, was employed in the preparation of this bulletin.[1] The 2,118 stomachs examined were collected in 39 States, the District of Columbia, and several Canadian Provinces. Of these, 1,340 were of adults and 778 of nestlings. Table I shows the distribution of this material, the stomachs being classified under adults, nestlings, and the State and month in which collected.

[1] For a list of items specifically or generically identified in the stomachs examined for this report, see pages 86 to 90.

TABLE I.—*Number of crow stomachs available for this investigation, arranged to show locality and month in which collected.*

State.	Adults.													Nestlings.			
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals by States.	April.	May.	June.	Totals by States.
Alabama	1	1	1	2	1			2	4	2		1	15	1			1
Arkansas						1							1				
California	1	2					1		1	1			6				
Canada	3	6	5	21	14	14	29	1	3	3	1		100		3		3
Connecticut	12	3		1	1	11				7	4	5	44				
Delaware							2						2				
District of Columbia	3	13	8	3	4	1			2	4	2	18	58	25	66	4	95
Florida	1	6	2	1		1				2			13				
Illinois	1		2	5	4	1	3	1		1	4	2	24		6		6
Indiana			1	1			6	3	8	1			20				
Iowa				1	4	5	3		3	1	2	1	20		9	3	12
Kansas	2	5		8	47	6	3	4	1	2	23	1	102	17	309	11	337
Kentucky			4	1						4			9				
Louisiana	6	3		2	2	1				2	1	2	19				
Maine				1	1	7	3						12			8	8
Maryland	7	12	14	3	51	44	16	7	10	1	5	29	199		146	15	161
Massachusetts	1	1	3	3	4	15	3			4	3		37			7	7
Michigan			11	5	6	5	2		3	2			34		29		29
Minnesota						2	2						4				
Mississippi						1			1		2		4				
Missouri				8	21	23			3				55	5	53	4	62
Montana			1					3					4				
Nebraska			1	1			1		3				6				
Nevada	1												1				
New Jersey	4	2	46	2			2		3	101			160				
New York		1	18	4	17	35	9	4	10	18	3	5	124		4	16	20
North Carolina	48												48				
North Dakota					2	2	1		3				8				
Ohio						6		5	1	14			26				
Oklahoma		1											1				
Oregon	5			1	2		2			1			11				
Pennsylvania	5	8	5	1		16	7	2					44			4	4
Rhode Island			1										1				
South Dakota				2					2				4				
Tennessee					1	1	1						3				
Texas	2		1								2	1	6				
Vermont					2					1			3		24	1	25
Virginia	20	4	1		3	3	1	5	1		2	6	46				
Washington									1				1				
Wisconsin	4	1	7	12	9	2	3	5	12	5	3	1	64		8		8
Wyoming					1								1				
Totals by months	127	69	132	89	197	203	100	42	75	177	57	72	1,340	48	657	73	778

Total adults, 1,340. Total nestlings, 778. Grand total, 2,118.

FOOD OF ADULT CROWS.

ANIMAL FOOD.

Animal food forms only 28.14 per cent of the yearly sustenance of the adult crow, but economically it exceeds in importance the vegetable portion. The assumption that the crow is primarily carnivorous and that the vegetable matter eaten is taken more from necessity than choice appears to be correct. Much of the vegetable food is of no economic importance, while there is little of the animal portion that is not intimately connected with the interests of man. The greatest proportion of animal food is consumed in May (52.44 per

cent). In the three months following a very uniform decrease is noted (46.98, 44.28, and 39.40), but even as late as September the animal portion constitutes nearly a third (32.32 per cent) of the food. Lower percentages from October to March, inclusive (14.29, 18.74, 13.18, 14.94, 10.97, and 16.05), reflect the struggle for existence which is the lot of the crow during the colder months. With April, however, comes relief, and the animal food again becomes conspicuous (34.09 per cent).

INSECTS.

In passing judgment on the economic value of most birds, nothing is of greater importance than a thorough understanding of their insect food. By this it is not meant merely that one should know the noxious forms eaten, the destruction of which is a benefit to man, but cognizance must also be taken of the complex relations between the various beneficial (predacious and parasitic) insects destroyed and the injurious ones upon which the bird commonly feeds. Some of this information is as yet unavailable, owing to the lack of knowledge of the interrelations between insect forms. Enough has been learned of the crow, however, by examination of 2,118 stomachs, 1,340 of which were of adults, and by reliable field observations to make possible the assertion that, for all practical purposes, sound judgment on the merits of the insect-feeding habits of the crow can be given. The series of stomachs available is sufficiently large and was collected under the varying environments of so many localities that the results obtained are probably close to a true average for the area in which the crow is common.

Insect food was taken by adult crows in every month of the year, though in January it amounted to only 1.29 per cent. February was represented by 4.85 per cent; March, 4.58; April, 14.72; May, 39.77; June, 35.95; July, 33.85; August, 35.07; September, 27.64; October, 11.51; November, 14.16; and December, 4.49. The insects identified belong to 12 orders, embracing no less than 455 specifically distinct forms. A discussion of this part of the crow's food will be taken up, order by order—Coleoptera (beetles), the order best represented in the crow's diet (7.58 per cent of the yearly food), being treated first.

Coleoptera (beetles).

The crow is primarily a terrestrial feeder. Its quota of beetles, therefore, is made up almost exclusively of species found on or near the ground, or those which, by the turning over of sticks, clods of earth, or dung, are secured from beneath the surface. The latter is a common method of feeding employed diligently by the crow from early spring to the beginning of autumn, when the usual crop of grasshoppers furnishes a more accessible supply of food.

SCARABÆIDÆ (May beetles, white grubs, June "bugs," rose chafers, tumblebugs, etc.).—Of the beetles, the Scarabæidæ are most important, forming 4.28 per cent of the annual food. Of these, May beetles (*Phyllophaga*) and their larvæ, white grubs, constitute by far the largest portion. Reference to the chart on page 42 will show that the area representing the amount of scarabæid beetles eaten practically coincides with the period of abundance of adult May beetles. These beetles, which at times entirely defoliate trees and shrubs and as larvæ extensively injure grass lands, corn, and other crops, are a particularly favorite food of the crow. Twenty-one species were identified in the material from crow's stomachs, a fact which in itself is indicative of the persistence with which these birds hunt. The percentages amount to little during the first three months of the year, but an indication of the year's brood is seen in April, when nearly 5 per cent is recorded. Then come May (the height of the May beetle season) with nearly 21 per cent; June with 10.06; and July and August with about half that amount. One hundred and fifty-six of the 197 adult crows collected in May had fed on these insects. Two birds had eaten nothing else, while several stomachs contained over 90 per cent of this food. In many cases the remains of these beetles were in advanced stages of digestion and formed but a small proportion of the stomach contents, but nevertheless they furnish striking evidence of the number of May beetles that crows are capable of destroying. Of course, such insect fragments are frequently the accumulated débris of several previous meals, but, when it is remembered that birds fill and empty their stomachs several times a day, the work the crow does upon May beetles is of the greatest importance. A female collected April 23 in Dallas County, Mo., had picked up 85 of these beetles, which, together with two other scarabæids, formed 42 per cent of the food. Two birds taken in the middle of May at Onaga, Kans., had eaten 29 and 28 respectively. One secured in Kentucky as early as March 31 had devoured 27 of these pests, while no fewer than 22 other adult crows had eaten 10 or more apiece.

Though crows are generally recognized as one of the important enemies of the white grub, the larva of the May beetle, it happens that the nestlings consume many more than the adult birds (see page 57), a circumstance logically accounted for, as the parent birds feed the more succulent food to their offspring. Of a total of 1,340 adult birds only 55, or 1 out of every 24, had fed on the larvæ of scarabæid beetles. These may not all have been of the genus *Phyllophaga*, as the identification of the remains of these grubs is often difficult owing to the rapidity with which they are digested. An adult crow collected in Manitoba in May had eaten 45 grubs along with fragments of adult *Phyllophaga*, the whole forming 70 per

cent of the food. One from Kansas secured at the end of April had made away with 17 grubs and 3 adults; and another, collected in North Carolina in January, gave evidence that in warmer climates where they do not burrow deeply in winter, these larvæ are preyed on the year round. This bird had eaten 17.

The stomachs examined show conclusively that the crow is a most effective enemy of the May beetle, especially in the adult form. Field observations have verified this conclusion repeatedly and have furnished many striking instances of the value of this bird during outbreaks of the insects.

Norman Criddle, of Aweme, Manitoba, who has observed the habits of these birds for many years in the Northwest, stated in a letter to the Biological Survey that crows—

> have also been observed here to collect practically every white grub [*Phyllophaga* sp.] thrown up by the plow on fields covering many acres. (1911.)

Benj. F. Gault, of Glenellyn, Ill., reports:

> Grass plots, both lawn and timothy, infested by these pests, I have known, on two marked occasions, to have been gone at most rigorously by them, the sod being torn up yards square in extent as thoroughly almost as though a pack of hogs had undertaken to do the work instead. (1912.)

H. W. Tinkham, of Fall River, Mass., in reporting his observations, presents evidence to show a source of supply of which the crow may take advantage:

> One crow picked up 47 May beetles on Sunday morning in the street in front of my house, and, as I had a powerful glass on him, I was much interested in his method. He would break the wing covers off, and, I think, the head, then gather a few, say four to six, into a pile, take two or three into the back part of the mouth and run his bill like a skewer through the balance. He made several trips to gather the 47—I think 8. (1901.)

Many species of these beetles are attracted at night to lights along roadways, fall to the hard pavements, and are unable to hide at the approach of daylight. Others may drop to the ground from the foliage of overhanging trees where they had been feeding during the night. Many also fall into the water of lakes and streams, where they are drowned, washed ashore, and there picked up by the crow; and still others, having bred, die from one cause or other, and may be found almost anywhere. Some of the May beetles in the stomachs of crows doubtless were dead when picked up, and in feeding on them no particular service was rendered, but enough is known of the methods pursued by these birds in their search for food to demonstrate that it is the living beetle, hid under sticks, stones, and clods of earth for which they search.

In view of the fact that white grubs frequently inflict serious damage on crops in spite of most vigorous efforts to control them, it is important that all their natural enemies be permitted to continue

their work unmolested. Among the most important of these is the crow. Before condemning these birds when found feeding in cornfields and grass lands, especially during the breeding season, it will be well to investigate the reason for their presence. The "corn-pulling" crow frequently has his gizzard filled with the insect enemies of this grain, a fact learned, often with considerable surprise, by many a farmer who, though skeptical, has been induced to open and observe the stomach of one of these birds shot in the cornfield.

The carrot beetle (*Ligyrus gibbosus*) and others of the same genus are eaten in considerable numbers. In contrast to May beetles, these insects inflict the greatest damage when in the adult stage, their larvæ feeding merely on decaying vegetation. Four crows collected in Dallas County, Mo., had secured 22, 21, 18, and 15 carrot beetles, respectively, and in several other cases these insects constituted over half the stomach contents. A closely related beetle (*Dyscinetus trachypygus*), found in wet situations, was eaten on several occasions. A particularly interesting case was that of a crow shot near the surf on Wallops Island, Va., which had eaten 36 of these beetles. Apparently the insects were present in great numbers (possibly dead ones washed in by the surf), as this bird, ignoring the harder parts, satisfied his appetite by merely snipping off the soft abdomens. No heads, thoraces, nor front legs, and only one wing cover, and a few middle legs were found. The hind legs and abdomens present furnished the evidence of the number eaten.

When opportunity presents itself, June bugs (*Cotinis nitida*) are taken freely by the adult crow, though the number of actual records of such work is not large. At least 20 were found in the stomach of one crow collected in Virginia in July. Another had eaten 19, and a third, 17. Euphorias, destructive beetles with habits similar to those of June bugs, are captured more frequently. The Indian euphoria (*Euphoria inda*) occasionally injurious to ripening fruits, especially peaches and pears, was fed to nestlings on numerous occasions, but the most noteworthy record among adult birds was that of one collected in Massachusetts in May, which had eaten 9. Two other species, *E. fulgida* and *E. sepulchralis*, also were identified. Vine-chafers, members of the genus *Anomala*, occurred in a number of stomachs, 20 individuals being found in one. Other phytophagous scarabæids were found, but in no case were insects of economic importance eaten in large numbers. Among these may be mentioned the goldsmith beetle (*Cotalpa lanigera*), the spotted vine-chafer (*Pelidnota punctata*), and the hermit flower-beetle (*Osmoderma eremicola*).

The dung-inhabiting scarabæids (Laparosticti) are common items of the crow's diet. The bird's habit of turning over and searching under cow dung brings him in intimate contact with small dung

beetles of the genus *Aphodius*, so abundant in spring and fall. The function of most of these beetles is that of scavengers, though one species, *A. granarius*, has been known to feed on and injure corn. A crow collected in California in February had eaten 50 of these. In view of their abundance, it is not surprising that upward of a score of these small beetles were frequently found in single stomachs. Members of the genus *Atœnius*, which live in rich earth, appeared less frequently than *Aphodius*. Tumblebugs (*Canthon* and *Geotrupes*) often form a considerable portion of the stomach contents, and associated with them frequently are the remains of other scavengers, *Copris*, *Onthophagus*, or the brilliantly colored *Phanœus carnifex*. While it can not be said that the crow is aiding man by consuming the scavenger scarabæids, unless it be in case of some species possessing herbivorous habits, as *Aphodius granarius*, it is doubtful whether it is doing serious harm. Feeding on these beetles may well be considered to have a neutral effect.

Carabidæ (ground beetles).—Only recently has anything like a fair value of predacious beetles been recognized, and economic entomologists are depending more and more on them in battling with insect pests. A most striking example of the effective work of predacious carabids is found in the activities of the larva of the imported *Calosoma sycophanta*, a foe of the gipsy moth in New England. When it is considered that carabid beetles, including members of such a highly beneficial genus as *Calosoma*, are frequently eaten by crows, a study of this portion of the food becomes of the utmost importance. It must be borne in mind, however, that certain ground beetles, as *Agonoderus pallipes* and a few members of the genera *Amara* and *Anisodactylus*, to some extent are herbivorous and have been known to do appreciable damage.

Ground beetles constituted 1.56 per cent of the yearly food of the adult crows examined, the bulk of these insects being taken in the months from April to September. May, with 5.54 per cent, was the month of greatest consumption, and June, with 3.24, stands next. In the fall and winter months these beetles did not form so much as 1 per cent of the food. Reference to the tabulation on page 43 will show that the monthly percentages of these insects eaten well represent their relative abundance at different seasons of the year. While fragments of carabids were found in a great number of stomachs, only rarely did they occur in numbers or constitute a large proportion of the food, the exceptional stomachs coming mainly from the West, where many of the smaller and apparently herbivorous species are extremely common.

The caterpillar hunters (*Calosoma* spp.) are probably the most conspicuous and valuable carabids eaten by the crow. Both adults

and larvæ are inveterate enemies of caterpillars, some species even climbing trees in search of their prey. The offensive odor and supposed warning coloration, especially of *C. scrutator*, *C. willcoxi*, and *C. calidum*, appear to have no deterring effect upon the crow, the nestlings of which ate even greater numbers than the parent birds. The brilliantly colored *C. scrutator* was identified in 16 stomachs of adults, six being the largest number found in any one stomach. The fiery hunter (*C. calidum*) was eaten more frequently, being present in 53 of the 1,340 stomachs. In one stomach, that of a bird collected in New York in June, were the remains of at least 15 of these beetles, forming half the bird's food. Another crow from New York had taken 10, and one from Manitoba, 5. Four other species of *Calosoma* were identified, but in none of the stomachs did they occur in large numbers.

Beetles of the less common genera *Carabus* and *Cychrus* were found in correspondingly fewer stomachs. The large, broad ground beetle *Pasimachus*, so common in some of the prairie regions of the West, was a regular article of food of crows collected in Kansas. One of these taken in May had eaten 16, while another secured in Illinois in November had devoured no less than 80 of the larvæ. Of the 1,340 adult crows, 57 had fed on *Pasimachus*. Both the larger and smaller *Scarites* (*S. substriatus* and *S. subterraneus*) were found, though seldom more than one to a stomach. Of the smaller active ground beetles with predacious habits those of the genus *Pterostichus* appeared most frequently, but never in large numbers. *Evarthrus* appeared in numerous stomachs from Kansas. Various species of *Harpalus* also were well represented, especially the large *H. caliginosus*, and *H. pennsylvanicus*, one of the commonest of the genus.

The extreme abundance of members of the genus *Amara* in some sections of the West would seem to indicate that they are more herbivorous than is generally supposed. A crow collected at Aweme, Manitoba, in May had eaten no less than 176, along with several *Harpalus;* another taken in April made away with 131 *Amara*, 6 *Platynus*, and fragments of a few other ground beetles; and a third had its stomach nearly half filled with the remains of 91 *Amara*, 57 *Harpalus*, and 2 *Calosoma calidum*. Several other stomachs collected in the Northwest contained upward of a score of these small beetles. Ground beetles of the genus *Chlænius*, insects which frequent damp situations, occurred in a number of the stomachs of Kansas crows. *Agonoderus pallipes*, which is at times destructive to seed corn, was present in only a few.

In the destruction of predacious ground beetles, especially the larger ones, as *Calosoma* and *Pasimachus*, the crow is doing man indirect harm. Fortunately the quantity of such food is small, only

1.56 per cent of the yearly food. This is somewhat atoned for by the presence in the diet of certain apparently herbivorous carabids.

Rhynchophora (weevils, billbugs).—In the control of weevil pests as a whole, the crow can not be considered an important factor. These insects form only 0.59 per cent of its food and on only two species does the bird feed to an extent sufficient for it to be considered even a moderate check on the increase of the insects. These are the clover-leaf weevil (*Hypera punctata*) and the imbricated snout-beetle (*Epicærus imbricatus*). The former, introduced from Europe many years ago, has gradually extended its range until it is now reported doing serious damage as far west as Idaho.[1] Of the stomachs examined, 107 contained remains of the clover-leaf weevil, an average of about 1 for every 12½ stomachs. Eleven was the largest number recorded in any one stomach, that being of a crow collected in New Jersey in March. The imbricated snout-beetle which is known to injure a variety of crops, was found in fewer stomachs (68), but in several instances in considerable numbers. A series of four stomachs secured at Sandy Spring, Md., in May contained 27, 25, 14, and 11, respectively. Clover-root curculios (*Sitona*), rhubarb curculios (*Lixus concavus*), and other species of *Lixus* occurred in a limited number of stomachs. Members of the genus *Thecesternus* were taken frequently by crows collected in the central and southern parts of the Mississippi Valley. Billbugs, including pests which feed to an injurious extent upon corn, small grains, and grasses, also entered into the crow's diet.

Other Coleoptera.—Other miscellaneous beetles comprised nearly 1 per cent of the crow's annual food. Common among these were the necrophagous and coprophagous forms, Silphidæ, Staphylinidæ, and Histeridæ. These beetles were taken about as frequently as scarabæids of similar habits and often appeared in the same stomachs. Their presence in the crow's diet is indicative of the bird's scavenger habits, and it would appear that on occasions the crow will search through carrion merely for these insects, leaving the offal as convenient bait for more. The larvæ of these beetles are taken as well. A crow secured in Alabama in May had fed on at least 29 larvæ of a *Silpha*. Another from New York had eaten 13. One shot in Dallas County, Mo., in June had devoured no less than 21 adults of the large staphylinid *Creophilus villosus*, as well as 3 of a species of *Necrophorus* and 9 of *Silpha surinamensis*, which together, forming 55 per cent of the food, lent strong circumstantial evidence as to the nature of the remains of a chicken and turtle found in the same stomach. Of larder beetles (Dermestidæ) the crow eats few. His-

[1] Parks, T. H., Journ. Econ. Entom., VII, No. 3, p. 297, 1914.

teridæ, small, shiny, hard-shelled beetles that live in carrion and probably feed on other insects found there, were present in a number of stomachs, though never forming a large part of the food.

Click beetles (Elateridæ) or their larvæ, wireworms, were present in 105 stomachs. In no month of the year, however, did these destructive insects form as much as 1 per cent of the crow's food. A bird taken at Aweme, Manitoba, in May had destroyed 72 wireworms and 1 click beetle. Mr. Stuart Criddle, who collected this bird, noted at the time it was shot that "wireworm beetles were all over the fields, and that the crows could be seen turning up cow dung, sods, and bits of sticks hunting for them." (1912.)

The late Prof. F. M. Webster, in writing of the natural enemies of wireworms, made the following statement:[1]

> Among the natural enemies the crow is doubtless the most useful, and what testimony we have on the subject goes to show that elaters and their larvæ constitute a large portion of its food. B. F. Aston, of White Creek, N. Y., on breaking up a crow's nest containing the unfledged young, found the crops of each of these to contain 70 or 80 snapping beetles. A more recent observation is recorded by Prof. Theo. G. Lemmon, of Westport, Mo., in a paper read before the State Horticultural Society at its twenty-ninth annual meeting. The professor shot and examined the contents of the crops of a number of crows about Lexington, Mo., where the ravages of wireworms had been very severe, and found that they contained a sufficient number of these insects to warrant the assurance that the crow is the untiring enemy of the wireworm.

From such reports it would appear that the crow is a more effective enemy of the wireworm than stomach examination indicates. It doubtless does good work during outbreaks of these insects, and were it possible to collect material under such circumstances much positive evidence of this trait could be secured.

A few long-horned and metallic wood-boring beetles (Cerambycidæ and Buprestidæ), stag beetles (Lucanidæ), leaf beetles (Chrysomelidæ), aquatic beetles (Dytiscidæ and Hydrophilidæ), and darkling beetles (Tenebrionidæ) also enter into the crow's diet, but in no case is their destruction of great importance. Beetles of small size are practically immune to the attack of crows. A single ladybird (*Megilla maculata*), for instance, is the only one of this fairly abundant family found in the entire series of 2,118 stomachs. The smaller species of leaf beetles also were lacking, though abundant and available in many of the situations in which the crow habitually feeds.

Orthoptera (grasshoppers, locusts, and crickets).

In many respects Orthoptera constitute the most important insect food of the crow. In bulk they are exceeded by beetles by only a fraction of 1 per cent, while the damage they inflict far exceeds that

[1] Ohio Agr. Exp. Sta., Bull. 46, p. 228, 1893.

done by the heterogeneous assortment of beetles eaten. The most serious insect plagues of history have been of grasshoopers and crickets, and in some of the Western States the ravages of the migratory species are matters of but yesterday. While the extremely serious outbreaks of early pioneer days may not be repeated, owing to man's encroachment and modification of the breeding range of these insects, the annual losses due to them throughout the country are nevertheless great.

The crow's yearly consumption of Orthoptera (most of which are Acrididæ, the short-horned grasshoppers) amounts to 7.34 per cent of the food, the bulk of which is taken during the latter half of the year. It is not until May that these insects enter strongly into the diet (4.29 per cent). June follows with 5.83 per cent, and then, in the increased amount of this food for July (14.04 per cent), is seen the arrival of the regular summer crop of these pests. August and September are represented with even greater quantities (19.14 and 19.24), and the decrease of the insects in October, November, and December is recorded rather irregularly by the percentages of 8.68, 10.73, and 2.07, respectively.

Acrididæ (short-horned grasshoppers, locusts).—The short-horned grasshoppers, or locusts as they are more familiarly known in those sections where, as migratory hordes, they inflict severe damage, constitute by far the greater part of the Orthoptera eaten by the crow. The percentages quoted above for the whole order may well be considered representative of this particular family. Of the 1,340 adult crows, 589 had partaken of grasshoppers. Some stomachs contained only a jaw or leg fragment, estimated as merely a "trace," while others were filled exclusively with the insects, in some cases over a hundred individuals being counted. Inasmuch as a bird's stomach frequently contains the indigestible parts of several previous meals, the large numbers obtained by counting grasshopper jaws is not so surprising. At the same time, when it is considered that an adult crow will eat enough in the course of a day to fill its stomach completely several times, the extent of its destruction of grasshoppers becomes apparent. The nestlings, which require still larger quantities of food for their rapidly growing bodies, are of even greater value in regions where these insects are plentiful (see p. 59).

An adult crow, secured in Indiana in August, had eaten no less than 123 grasshoppers, these forming over two-thirds of the food. One taken in Maine in May had picked up 108 of a little "grouse locust" (*Tettigidea* sp.). These chunky little grasshoppers pass the winter in the imago or adult stage and early in spring are often found abroad in considerable numbers. A series of 12 birds secured in Manitoba in July had fed extensively upon grasshoppers, which were then swarming in the fields. One bird had eaten

as many as 91, another 86, while the average for the 12 was over 57 grasshoppers apiece, about 46 per cent of their food. Two collected in Kansas in May had fed on 86 and 80 grasshoppers, respectively, these forming 80 per cent of the food in each case. The 70 acridians eaten by a crow secured in British Columbia entirely filled the stomach except for a mere trace of an ant and a spider. Twenty-eight other stomachs of the series examined contained 20 or more of these insects. Orthopterous eggs occurred in several, but in nearly every case there was evidence that these came from the bodies of females eaten rather than from burrows in the ground.

Crows apparently have no preference as to the species of grasshoppers eaten, taking whatever comes in their path. The fragile nature of the bodies often eliminates the possibility of specific identification soon after the insects are swallowed, so the number of species recorded from stomach examination is small. Several of the most destructive forms, however, have been recognized, notably, the red-legged locust (*Melanoplus femur-rubrum*), the two-striped locust (*M. bivittatus*), the lesser migratory locust (*M. atlanis*), and the large lubber grasshopper (*Brachystola magna*).

Crows have long been recognized as persistent hunters of grasshoppers, and in late summer and fall they may be found in small squads of a family or two searching grass lands and grain stubble for these insects. The peculiar antics of the birds in attempting to capture elusive individuals have been noted by many field observers, and farmers generally have appreciated the good work the crow does at this time of year.

Gryllidæ (crickets).—Crickets were found in 75 of the 1,340 stomachs, frequently associated with grasshopper remains. Most of these were the common black ground crickets of the genus *Gryllus*, and in a few stomachs they were present in considerable numbers. A crow secured in New Jersey in October had eaten 38, together with 11 grasshoppers, and another secured in Wisconsin in August had nearly filled its stomach with 20 crickets and 3 grasshoppers. Only two stomachs contained the remains of mole crickets (*Gryllotalpa borealis*), but it is highly probable that a series collected in areas where these pests are plentiful would show a larger proportion.

Locustidæ (katydids, green or long-horned grasshoppers, stone crickets, etc.)—Katydids and allied insects occurred in comparatively few stomachs. Over much of the crow's range these are of little economic importance, but in the Northwest the crow comes in intimate contact with a notorious pest, the western cricket (*Anabrus simplex*). Six stomachs collected at Okanogan Landing, British Columbia, in June contained these insects in considerable numbers, in several cases to the extent of nine-tenths of the contents.

OTHER ORTHOPTERA.—Fragments of a few roaches (Blattidæ) and the odd egg clusters of rear-horses (Mantidæ) were the only other orthopterous remains found.

Lepidoptera (caterpillars, moths, and butterflies).

Lepidopterous remains in the food of the crow are composed almost entirely of the larvæ, caterpillars, most of which are eaten by nestling birds (see p. 60). In bulk this portion of the diet forms only 1.56 per cent of the yearly sustenance of the adult bird, compared with 5.34 per cent for the nestling. June is the month best represented, when these insects form 6.41 per cent; May is second, with 2.71; and September, third, with 2.12. Of the total number of stomachs, 1,340, lepidopterous remains were found in 297, and in a few instances formed a considerable part of the contents. A particularly noteworthy stomach was that of a crow obtained in Michigan in May. This bird had eaten 483 small caterpillars, apparently of the genus *Crambus*, to which belong the grass moths. Another collected at the same time and place had its stomach two-thirds full of caterpillars of the same kind. A bird taken in Wisconsin in September had eaten at least 50 small unidentified moths, which amounted to 90 per cent of the food; and in at least 7 other stomachs more than 10 moths or caterpillars were present. In only one instance was a butterfly identified.

Cutworms (Noctuidæ) were found more frequently than the larvæ of any other family. Among these were identified the cotton worm (*Alabama argillacea*), the army worm (*Cirphis unipuncta*), and the fall army worm (*Laphygma frugiperda*). The large larvæ of several of the silkworm moths (Saturniidæ) were detected, and in a limited number of stomachs were those of the tussock moth (*Hemerocampa leucostigma*), the spring canker worm (*Paleacrita vernata*), and eggs of the tent caterpillar (*Malacosoma americana*).

Field observers have often noted the energy with which crows hunt for caterpillars during the period when there are callow young to feed, especially in regions where an outbreak of one or another of these pests has afforded an abundant supply of nutritious food. The work of these birds on the army worm in Pennsylvania was recognized by Dr. B. H. Warren, who witnessed their activities while feeding. He reported:[1]

> The viscera of 23 crows, old and young, which were captured in different counties of the State, and in localities where army worms were abundant, were in many instances found to be gorged with the remains of these larvæ. Crows also ate the pupæ. * * * A crow would eat a handful of the worms at a single meal; and the number which a single bird would devour in a day was immense.

[1] Pennsylvania State Col. Ann. Rpt., 1896, p. 212.

In a recent report, J. T. Zimmer of the Department of Entomology of the University of Nebraska states:

> Crows materially reduced numbers of the fall army worm (*Laphygma frugiperda*) during the fall of 1911 in southeastern Nebraska. These birds were then migrating and more common than at other seasons. This insect was quite injurious in winter wheat fields during the season mentioned in this part of the State.

In Massachusetts, where the gipsy and brown-tail moths have defoliated extensive areas of woodland and have caused great expense both to State and National Governments, crows have done good work.

In this connection Charles E. Bailey, as assistant to Mr. Forbush, reports[1] that—

> a brood of crows (four young and two old birds) came * * * at 8 o'clock and stayed until almost 9. * * * They would go to a cluster of pupæ and caterpillars and eat some, but drop more than they ate. I think they took more pupæ than caterpillars * * *. The young birds took many more than the old ones. * * * I think the six crows took 200 pupæ while in sight. Some of the time they took them as fast as a hen would pick them up.

O. E. Bremner, a horticultural inspector for the State of California, in a letter to the Biological Survey, reports that—

> in the spring of 1905 a species of climbing cutworm attacked the vineyards in Sonoma County on low land along the Russian River and before we had a chance to do anything, had stripped 10 acres or more of every vestige of green, even the stems and buds, back to the old wood. When I arrived on the scene, where thousands of the worms were being destroyed by hand picking, I found large numbers of crows assembled and busily engaged in hunting out the fat worms. There has not been a repetition of the attack since and I attribute this, at least partly, to the crows.

Hemiptera (*bugs, including cicadas, leaf-hoppers, stinkbugs, squash bugs, etc.*).

Bugs of various kinds form less than 1 per cent (0.63) of the annual food of the crow. August is the month of greatest consumption, with 2.92 per cent, and June is next, with 1.75. Of the two orders into which these insects are divided, Homoptera and Heteroptera, the latter is better represented. This may be due to the small size of many of the homopterans and to the fact that comparatively few are strictly terrestrial. Evidence secured from the stomachs examined, however, shows that the periodical cicada (*Tibicen septendecim*) may at times enter strongly into the diet, especially of nestling birds (see p. 61). A series of stomachs of both old and young crows was collected in May, 1913, at Onaga, Kans., at a time just prior to the emergence of a brood of these insects. The birds fed upon them ravenously, most of those eaten being in the last pupal stage and probably dug out from their retreats not far below the surface of the ground.

[1] Forbush, E. H., Useful Birds and Their Protection, p. 129, 1907.

Of the true bugs (Heteroptera), members of the stinkbug family (Pentatomidæ) are most frequently found. These strong-smelling insects occurred in a large number of stomachs, though seldom in great quantities. Inasmuch as some insects of this family are predacious, others herbivorous, and still others of varied food habits, an indiscriminate feeding on them would result in no great harm or good. *Podisus*, *Euschistus*, and *Brochymena* were the genera most frequently found. Assassin bugs (Reduviidæ) are not uncommon articles of food. Among those identified were the wheel bug (*Prionidus cristatus*), two species of *Melanolestes*, *Apiomerus crassipes*, and *Sinea* sp., all of which are predacious. Of the Lygæidæ, the notorious chinch bug (*Blissus leucopterus*) only is worthy of mention. A crow collected in Kansas in November had eaten 30 of these pests.

Diptera (flies).

Flies form a very small and, on the whole, unimportant part of the crow's food, constituting less than half of 1 per cent. Of these, craneflies (Tipulidæ) are of greatest economic interest, as their larvæ, "leather-jackets," are destructive to grass lands. The adults, pupæ, larvæ, and eggs of these insects have been taken from crows' stomachs; the eggs, however, appearing in most cases to have come from the bodies of females which the bird had eaten and partly digested. Stomachs have been opened in which the contents were blackened by many thousands of these minute ellipsoid eggs, when only a trace of the fragile parent remained to tell the story whence they came. Muscid and sarcophagid flies, their puparia and larvæ—the latter stages often associated with carrion—were present in many stomachs, and in the case of some nestlings occurred in considerable numbers. Marchflies (Bibionidæ), horseflies (Tabanidæ), robberflies (Asilidæ), and soldierflies (Stratiomyidæ) made up the bulk of the remaining food classified under this order.

Hymenoptera (ants, bees, wasps, etc.).

Of the hymenopterous insects found in crows' stomachs, ants outnumbered all other groups, but even they formed a negligible portion of the diet, as all the Hymenoptera combined formed only about two-thirds of 1 per cent of the yearly sustenance. In only one stomach were ants present in considerable numbers, and in this several hundred composed about three-fourths of the contents. Some of the larger species eaten, as *Camponotus herculeanus pennsylvanicus*, and some species of the genus *Formica*, probably are picked up by the crow whenever met, but most of the smaller forms unquestionably are eaten accidentally with carrion or dead insects over which they swarm. In either case the quantity taken is so small that the economic considerations involved are practically negligible.

Records of crows feeding on bees (Apoidea) are few and usually restricted to single insects in individual stomachs.

Wasps (Vespoidea and Sphecoidea) of various kinds are not uncommon articles of diet, and to certain beneficial species attention must be called. Digger wasps (*Tiphia*), one of the most important insect enemies of the white grub, were found in 19 of the 1,340 stomaches, a total of 24 individuals being eaten. This is indeed a limited number and is very small in comparison with the enormous number of adult May beetles (*Phyllophaga*), parents of the white grub, which the crow destroys. This may be explained by the fact that most of the *Phyllophaga* eaten are adults, the grubs, which the wasps parasitize, being taken less frequently. Of course, it is highly probable that some of the larvæ eaten had been parasitized and then their consumption by the crow resulted in the destruction of the eggs or larvæ of these beneficial insects. It can not be claimed, though, that in its feeding on white grubs the crow is doing anything but good, regardless of how many may be parasitized, as in no way are the interrelations between the wasp and the grub disturbed by this indiscriminate destruction. Of the other wasps, members of the genera *Polistes* and *Odynerus* appeared most frequently. Sawflies (Tenthredinidæ), which include the injurious currant and pear slugs, are seldom eaten by crows. Parasitic ichneumons were found in a few stomachs, though never in great quantities.

Miscellaneous insects.

Other orders of insects are poorly represented in the crow's food, together forming less than three-fourths of 1 per cent. Most of these are aquatic forms, occurring in stomachs of crows secured in marshy regions. Dragonflies (Odonata) and their nymphs, caddisflies (Trichoptera) and their larvæ inclosed in odd cases of sticks and stones, mayflies (Ephemeridæ), dobsons (*Corydalis cornutus*), and a few other neuropterous insects comprise the bulk of this food. In no case were insects of economic importance taken in large numbers.

SPIDERS.

While spiders form a large portion of the food of nestling crows (see p. 62), the adults eat but few—less than half of 1 per cent of the annual food. Most of these belong to the wolf, or running, spiders (Lycosidæ), terrestrial forms, some species of which grow to considerable size. A few jumping spiders (Attidæ), daddy longlegs (Phalangida), and a single orb-weaver (Argiopidæ) also were found. Spiders as a whole, being indiscriminately predacious, are doubtless beneficial. The wolf spiders, however, which comprise the largest portion of this part of the crow's food, are restricted in their feeding to terrestrial forms, so that many of the injurious herbivorous species

and practically all flying insects, among which are many of the most noxious pests, seldom come within their reach. The exact status of these spiders, so abundant in some parts of the western prairie country, is as yet not fully understood.

CRUSTACEANS.

Stomach examination of adult crows showed that crustaceans constituted 1.17 per cent of the yearly food. By far the largest proportion of this consisted of crawfish, which were present in 150 of the 173 stomachs in which crustaceans were found. They were eaten in every month, but were taken in largest quantities in March and April, when they comprised over 3 per cent of the stomach contents. Birds collected in southern States had eaten much more of this food than their northern relatives. In fact, a series of 108 stomachs collected in the Gulf and South Atlantic States gave a percentage of 7.40, over twice the proportion recorded for the full series of 1,340 adult birds collected throughout the country. A few birds had fed almost exclusively upon these pests, while series of stomachs secured in areas where crawfish were plentiful indicated that this food was sought quite systematically, as nearly every bird had partaken of it. This work is especially noteworthy in view of the injury these crustaceans inflict upon corn and cotton in some sections of the South and the damage which is sometimes done to dikes by their tunneling.

Crustaceans other than crawfish were eaten in only small quantities. These were creatures of no special economic importance, as sowbugs (*Armadillidium* sp.), found commonly in damp cellars and under rotten logs, a few small amphipods, and, in one stomach, a sandbug (*Emerita talpoida*). A few other unidentified crustacean remains may have been of marine origin and were perhaps picked up on the beach at low tide.

MOLLUSKS AND OTHER AQUATIC INVERTEBRATES.

The crow is a persistent feeder along lake shores and river banks, where it picks up a considerable amount of aquatic food. The seashore also, with its ebbing tide exposing daily an ample supply of marine forms, is a common feeding ground of crows which roost or nest for some miles inland. The latter locality is an especially favorite one for the birds gathered along the Atlantic coast during the winter months. In these situations mollusks of many kinds frequently enter into the crow's diet. Remains of aquatic and land shells were found in stomachs throughout the year, though in bulk they compose but a small proportion of the bird's food (0.31 per cent), and in no month does the quantity exceed 1 per cent. This part of the crow's fare can be considered as only of a neutral nature.

In feeding on the larger mollusks, which it frequently secures, the crow displays an interesting method of obtaining the mussels from their hard, protecting shell. This is explained in an article on the habits of the herring gull, by George H. Mackay,[1] in which the writer claims that crows as well as the gulls possess this habit. He says:

I cite as an instance of their ingenuity that in winter I have seen them carry up in their bills to a height of 25 to 35 feet into the air a large sea clam *Mactra solidissima* Gould), measuring 6½ inches by 4½, for the purpose of breaking the shell (that they might avail themselves of the contents for food) by dropping it on the hard beach. I have seen them carry up the same clam four times when it failed to break on account of insufficient height; but they will carry them up higher after several ineffectual attempts and thus obtain the desired results; they also carry up scallops (*Pecten concentricus*) and mussels (*Modiola modiolus*) * * *. That they usually succeed seems certain, for I have seen them eating them, and have noticed the broken shells, minus the contents, lying on the beach surrounded by their tracks. They vary this mode of proceeding in some places by carrying and dropping the clams on a cake of ice, or on a rock.

A. B. Klugh, of Queen's University, Kingston, Ontario, has written that on the coast of New Brunswick the American crow sometimes feeds on sea urchins (*Strongylocentrotus droëbachiensis*), carrying them off to the woods to eat.

FISHES.

Fish remains were found in stomachs collected in every month of the year, though in bulk they formed little over half of 1 per cent (0.56), and there is no question that most of this should be classed as carrion. As much of it was eaten in winter, however, when few carrion insects are about, little evidence was available as to the character of this food. The crow's worth as a scavenger of dead fish is mentioned under the heading "Carrion" (p. 40). Crows at times capture small fish in shallow water, but this work is never carried to an extent seriously injurious to the supply of food or game fishes. Stomach analysis shows that among those which might be so captured are shiners (*Notropis*), hornyheads (*Hybopsis*), carp (*Cyprinus*), and fallfishes (*Semotilus*).

In feeding on live fish the crow displays in a moderate degree the skill of the kingfisher. In this connection Charles Hallock has written:[2]

Almost daily, in front of my residence on the Neuse River (Newbern, N. C.), I see the crows hovering and circling over the surface of the water looking for fish, very much after the manner of the sea gulls. They will swoop down and scoop their little prey deftly very often without breaking the surface.

[1] Auk, IX, p. 222, July, 1892.
[2] Forest and Stream, XXXVIII, p. 320, April 7, 1892.

REPTILES AND AMPHIBIANS.

Reptiles and amphibians are frequently found in the stomachs of crows, both adult and young, though the latter take a much larger quantity (see p. 63). Such food formed 1.37 per cent of the diet of the old birds, reaching a maximum in April, when it totaled 4.38 per cent. June and July were represented with about 3 per cent each and May and August with about 2. In no other month did such food form as much as 1 per cent.

Reptiles.

Reptiles, including turtles, lizards, and snakes, were less frequently taken than amphibians. They occurred in 76 of the 1,340 stomachs. As in the case of fish remains, it is often impossible to determine whether reptilian food was picked up as carrion or acquired by the predatory activities of the crow. It is highly probable, though, that at least half the reptiles eaten were dead when found.

The turtles secured were usually young ones, some of which apparently were painted terrapins (*Chrysemys picta*) and box turtles (*Cistudo carolina*), though the disintegrated condition in which they were found prevented accurate identification. Lizards were found in 8 stomachs, but in only one could even generic identification be made. Snakes, discovered in 48 of the 76 stomachs in which reptiles occurred, formed the bulk of the reptilian food. In only two instances could more accurate identification be made, a garter snake (*Eutænia* sp.) and a blue racer (*Zamenis constrictor*) being recognized.

It is doubtful whether in its consumption of reptiles the adult crow is doing any appreciable harm or good. So many of those eaten are in the form of carrion that the remaining portion is negligible in quantity. At the same time those captured alive appear to be about equally divided between beneficial and injurious forms. Turtles are to a certain extent injurious, lizards largely beneficial, and snakes (such as the crow eats) divided between the small insectivorous and rodent-eating forms and some large species, as racers, which prey upon the eggs and young of insectivorous birds. There is no evidence that crows subsist to any extent on poisonous reptiles, even in areas where the latter are abundant.

Amphibians.

Toads, frogs, and salamanders, from their almost exclusively insectivorous habits, must be ranked among the most beneficial creatures preyed upon by the crow. The first of these especially come in contact with many of the insect pests of garden and field; frogs necessarily confine their activities to aquatic or at least moist situations, where they feed on insects less intimately connected with the

economy of man, while salamanders, the least valuable of the three, are found in damp places, where occasionally a foraging crow, turning over sticks and stones, may find them. In the examination of stomachs it was found difficult in many cases, where only a small portion of the skeleton remained, to distinguish between frogs and toads, but enough identifications were made to establish the fact that frogs greatly outnumbered toads in the food of the crow. The crow's favorite habit of hunting in marshy areas probably accounts for much of this, and then, too, toads are largely nocturnal in their habits, remaining in concealment during most of the day. The fact that the latter, owing to their clumsiness, frequently meet with fatal accidents warrants the assumption that a portion of the toads eaten must be classified as carrion. Amphibians of various kinds were present in 153 of the 1,340 stomachs of adult crows, in 86 of which they were identified as frogs. In only 3 were toads recognized, though doubtless some of the remains not generally determined were of these creatures. Salamanders were detected in 29 stomachs.

WILD BIRDS AND THEIR EGGS.

The crow's antagonism to other native birds has been the basis of complaints against it from the earliest days of American ornithology, and the various changes that agriculture and the general advance of civilization have made upon the environments of many birds have had a tendency even to aggravate this evil. The establishing of game farms and preserves, where large numbers of game birds with their eggs and young are confined to comparatively small areas, has brought this obnoxious habit of the crow to the immediate notice of game wardens and game raisers. In public parks and rural districts where the crow has had protection along with other species, it has at times assumed the rôle of a most persistent nest robber, making daily visits in early morning hours among the trees and shrubs in search of nests of smaller species; and throughout our agricultural districts in general, where formerly much of the timber and brush was an effective cover for birds, the crow now has a better chance to ply this nefarious work. Complaints are made also of the crow's predatory habits in environments unaltered by the hand of man, as in nesting colonies of herons, rails, ducks, and other waterfowl. From this it would seem that the crow's bird-killing and nest-despoiling habit is not a recently acquired one, although modern conditions doubtless have aided the bird considerably.

In the search for evidence bearing on this trait of the crow stomach analysis alone does not always tell the whole story; it is important, however, especially in refuting wild and groundless accusations sometimes made against the crow by persons who have let a few personal observations, limited usually to restricted areas and peculiar

conditions, suffice as evidence. Since stomach analysis falls short in identifying such readily digested food as the tender flesh of young birds, effort was made to secure from reliable observers all possible data bearing on this phase of the crow's food habits. Remains of eggs also are almost certain to escape notice when none of the shell has been eaten, and, in the opinion of some, this factor alone disqualifies stomach analysis as a method of investigation for determining the extent of such depredations. It must be borne in mind, however, that even when crows resort to "sucking" eggs, the shell is at least punctured and small fragments most likely reach the stomach. Even minute quantities of such material are readily identifiable and would seldom escape notice. Eggs up to the size of a robin's will be crushed and swallowed by the crow with almost the entire shell held together by the shell membrane, so that criticisms of this kind must be restricted to cases where larger eggs are eaten. Fragments of these have been found in a sufficient number of stomachs to indicate that crows are in no way averse to eating the shell of eggs, and, in fact, in many cases it appeared as if they took special pains to consume all they found. The writer feels confident that very few instances of egg eating by crows escape notice in stomach analysis.

The fact that the remains of young birds rapidly disappear when once in the stomach of a crow, and that it is merely the shell of an egg that can be detected and its bulk estimated, has resulted in comparatively small percentages for such items. This circumstance has led to an erroneous impression of the extent and importance of the work. Here, then, is presented a case where the percentage-by-bulk method of estimating bird food must be strengthened by other means of computing the merits of a bird's diet. It is essential that we know the frequency with which crows will resort to such activities, determined by the ratio of the number of stomachs in which wild birds and their eggs were found to the total number examined. It is also of value to know the total number of birds or clutches of eggs eaten by a definite number of crows. This latter information is of greatest importance in passing judgment on the status of nestling crows, where often the remains of a single bird or clutch of eggs is passed around to all members of a brood. To determine the exact number of individuals contained in such a series of stomachs is at best a difficult task and in many instances impossible.

Wild birds and their eggs comprised 0.32 per cent of the food of the 1,340 adult crows examined. July was the month of greatest consumption, when they formed 1.66 per cent of the food. June was second, with 0.90, and May third, with 0.70 per cent. In no other month did such food amount to as much as one-fourth of 1 per cent, August and October being wholly unrepresented. Wild birds were

found in 34 of the 1,340 stomachs, an average of about 1 in every 39½, while their eggs were present in 13, or 1 in about every 103. As in no case were both birds and eggs found in the same stomach, a total of 47 out of 1,340, or 1 out of about 28½, would represent in a way the extent of the adult crow's depredations on other species. In the examination of stomachs it was found that the greatest quantity was eaten in July. This result was obtained because in three cases wild birds constituted over half the stomach contents. June, however, is the month when this food is secured most frequently. Twenty of the 203 birds secured in this month had fed on wild birds or their eggs. In May, 10 out of 197 had subsisted on similar food; and in the remaining months, when such depredations were confined to wild birds only, no eggs being taken, this kind of food was less frequent. It occurred in four of the stomachs collected in April; in three each in January, March, and July; and in one each in February, September, November, and December.

It is apparent, then, that the greatest consumption of birds by adult crows takes place during the breeding season, in May and June, and in addition there must be considered an even greater proportion of such food fed to their nestlings during the former month (see p. 64). At this time the demand for animal food of the most nutritious kind is imperative with parent crows, which may have as many as six or seven ravenous young to feed. Identification of species, whether birds or eggs, from the remains in the stomachs is seldom possible. The birds eaten are usually nestlings of smaller species, whose tender bones furnish poor material for accurate determination, and the eggshells are usually broken to small bits, from which it is difficult to judge either size or markings. A stomach of one young crow from Kansas contained one foot each of a red-headed woodpecker and an upland plover. Warblers were questionably identified in two stomachs, and single individuals of the following birds were found in others: Ruffed grouse, bobwhite, goldfinch, bluebird (?), song sparrow (?), meadowlark (?), and indigo bunting (?). The shell of the egg of a robin or wood thrush was recognized in two stomachs, that of a catbird in one, and of a meadowlark (?) in another.

While most records of attacks by crows upon other birds are associated with species of more or less confiding habits, as robins, catbirds, and brown thrashers, other species also suffer occasionally. Below is a list of birds which, according to records of the Biological Survey, have been maltreated by their black relatives. The bulk of the information was received in response to letters of inquiry sent to reliable observers:

Pigeon guillemot, herring gull, glaucous-winged gull, tern (sp.), anhinga, Baird cormorant, mallard, canvas-back, ibis (sp.), Ameri-

can bittern, Ward heron, little blue heron, black-crowned night heron, clapper rail, Wayne clapper rail, Virginia rail, coot, spotted sandpiper, upland plover, Wilson plover, bobwhite, ruffed grouse, prairie chicken, sharp-tailed grouse, pheasants (various introduced species), red-shouldered hawk, osprey, flicker, kingbird, least flycatcher, horned lark, blue jay, red-winged blackbird, meadowlark, Baltimore oriole, bronzed grackle, purple finch, goldfinch, vesper sparrow, English sparrow, chipping sparrow, field sparrow, song sparrow, cardinal, barn swallow, cedar waxwing, yellow warbler, mockingbird, catbird, brown thrasher, wood thrush, and robin.

Not all such misdeeds, however, should be charged against the common crow. It is apparent from the localities where some of these reports originated that the fish crow (*Corvus ossifragus*) or the northwest crow (*C. caurinus*) may have been to blame. As a matter of fact, these maritime species appear to be much greater despoilers of eggs than their inland relative, but they are frequently confused with the common crow and their misdeeds heaped upon its head.

The molesting of small song and insectivorous species by crows about dooryards involves misfortunes which come intimately to the attention of a great number of bird lovers. As the published evidence on this point is already voluminous, only a few reports are presented here.

John Lewis Childs, of Floral Park, N. Y., reports:

It is my opinion from a close observation of crows for a period of 20 years that they do much more damage than good, not alone in the destruction of corn and poultry, but particularly in respect to the large number of smaller birds which they destroy during the breeding season. For years I have noticed that four-fifths of the nests of the robin, the wood thrush, and catbird, and many others, are robbed, either of eggs or the young birds before they are able to leave the nest. This is done almost wholly by crows, and the number of eggs and young birds of the smaller species which a pair of nesting crows will destroy during the breeding season is, in my opinion, enormous. Of course, birds like robins, which nest near houses, are not subject to this robbery so much as those which breed farther away. Yet, year after year a few crows will come sneaking about the trees and shrubbery close to my house immediately after daybreak, scanning every possible location that might contain a nest of eggs or young birds, and the number of nests that are robbed in this way right under our very nose is considerable. (1911.)

Frank M. Chapman has placed in the following forceful terms his conclusions regarding the relation between the crow and the smaller species:[1]

While, from the nature of the case, birds' eggs and young birds can form but a small portion of the animal food supply of the crow, I believe it to be indisputable that during the nesting season they constitute a large percentage of the crow's food. Nest robbing is not occasional, but is the characteristic

[1] Chapman, Frank M., Economic Value of Birds to the State: N. Y. Forest, Fish, and Game Commission, p. 39, 1903.

habit of the crow. Not only do they eat eggs and young birds, but they feed their offspring on them. Doubtless few crows live through May and June without preying on smaller birds, and the possibilities are that almost any one of the birds destroyed (either in the egg or out of it) is of greater economic value than the crow. The crow, therefore, in addition to the direct damage it may do to our crops, robs us of the services of birds far more desirable than itself. Even if the crow, aside from its cannibal-like propensities, was wholly beneficial, it would not, it seems to me, render us as great a service as would have been performed by the birds it destroys. In short, in my opinion the crow is one of the worst enemies of our small insectivorous and seed-eating birds, and as such is undeserving of protection."

Louis A. Fuertes, of Ithaca, N. Y., writes:

The smaller birds, notably robins, thrushes, etc., suffer badly here, crows being very bold and coming into the yards in the suburbs and taking young robins from nests on the houses and even eating them in full sight on the lawns. Of this I have several records. (1912.)

F. H. Mosher, of Melrose, Mass., who has done considerable field work in connection with the economic value of birds in his State, asserts:

During the past season I found two pheasants' nests and one of a grouse that had been robbed by crows. In this vicinity, where the gypsy and brown-tail moths are plentiful, the small birds have a hard time to bring through their young because of the crows. The moths denude the trees, so the crows can easily find the other birds' nests and destroy their eggs and young. (1911.)

Le Roy M. Tufts, of Farmington, Me., has written the Biological Survey as follows:

For three weeks I arose at daylight and watched in my own and neighboring orchards, and during that time I detected crows in the act of robbing nests no less than 17 times. The next spring I trapped, poisoned, and shot about 50 of the black vandals, and these in my own and neighboring orchards, effectually preventing further depredations on the robins' nests; and, as I have followed up this plan each year, the increase of birds in this locality has been most gratifying. Whereas there were but 8 or 9 robins' nests in my orchards 10 years ago, last year I counted some 30 nests of the robin and many other birds, such as the cedar waxwing, thistle-finch, etc. (1904.)

It is a common accusation against the crow, especially among sportsmen, that it is one of the most destructive enemies of woodland and prairie nesting game birds. In a measure these complaints are probably well founded, more particularly as regards those species that habitually seek cover in which to breed, and of which they have been largely deprived by the advance of agriculture. Under such conditions the crow probably now enjoys an advantage which it did not possess formerly. In the readjustment of the relations between it and its feathered prey, which has doubtless taken place, such birds as the ruffed grouse and bobwhite are the losers.

Isaac E. Hess, of Philo, Ill., relates an instance of the destruction of a prairie chicken's nest by the crow.[1]

* * * A few days since, a farmer told me of a crow and prairie-hen episode of which he was an eyewitness. He was plowing in a field where he had previously located a prairie-hen's nest containing 14 eggs. The nest was beside a fence between two adjoining fields, and in consequence was in little danger of being disturbed.

His attention was attracted by an unusual commotion, and, drawing nearer, he saw a fight in which the hen was bravely defending her property. As he advanced to the rescue (he afterwards saw his mistake), both adversaries flew away. He found the nest sadly disturbed and four eggs punctured by the crow's sharp beak. Removing the broken shells, he returned to his work. The prairie hen, owing to its shy nature, was slow in returning, but before the farmer could plow around the field the crow (which, by the way, has never been accused of timidity) had made sad havoc of the remaining eggs.

"Crows are very destructive to eggs of wild fowl, especially ducks, partridge, sharp-tailed grouse, and prairie chicken," writes W. D. Black, of Margaret, Manitoba, and then adds, "Though prairie chicken are still very common, I have known 12 out of 15 nests to be robbed in one week. Crows are their greatest enemies * * *." (1912.)

The nests of ducks, rails, and other waterfowl also are attacked, and when crows make it a point to rear their young within easy reach of the breeding marshes of these birds, the chances are poor for the latter hatching their first laying of eggs.

Maj. Allan Brooks, addressing the Biological Survey from Okanogan Landing, British Columbia, claims that crows there—

destroy at least three-fourths of the nests of wild ducks; only in exceptional cases are the first layings of mallards hatched. Grouse do not suffer much except the sharp-tailed. The northwest fish crow (*Corvus caurinus*), found only on the coast and coastal valleys, is a far worse pest than the western crow (*C. b. hesperis*). The latter does some service in destroying grasshoppers, the former lives mostly on animal matter * * *. (1911.)

C. Wm. Beebe, of the New York Zoological Park, reports:

In the New York Zoological Park a few individual crows before, during, and after the nesting season acquire the habit of feeding on the eggs and young of the mallards which breed here. Altogether we have lost about 400 or 500 ducklings and many score of eggs. The former are often snatched from the water as they are swimming. When the particular marauders are killed the other crows in the park do not cause any trouble. (1911.)

Heron rookeries, especially those of the black-crowned night heron, are favorite resorts for marauding crows. These herons appear to be utterly helpless before the attacks of their more wily and aggressive enemies, and the total destruction of at least one laying of eggs is inevitable where nesting crows are at all abundant.

[1] Oologist, XVII, No. 9, p. 136, Nov., 1900.

From North Dakota, Alfred Eastgate, warden of the Stump Lake National Bird Reservation, writes:

> Last summer I saw a colony of between 300 and 400 nests of the black-crowned night heron entirely cleaned out by the crows. Ten per cent of the eggs of all the birds are taken by the crows that nest about the shores of Stump Lake. I have seen 29 nests of canvas-backs in one marsh eaten by them in one day. (1912.)

Robert P. Sharples, of West Chester, Pa., finds a mitigating circumstance in the raiding of early layings of heron eggs which would indicate that the depredations of crows may not always result in dire consequences. In a letter to Dr. B. H. Warren he says:

> I do not object to crows raiding the early heronries. I believe that nature has made a mistake in teaching these birds to nest so soon. The first eggs are always laid so that when the young hatch they are liable to destruction from storms. Then the old birds will not raise a second brood. But if the first-laid eggs are destroyed soon after deposition, then a second laying comes near a month later, and the birds have a far better chance of arriving at maturity. (1914.)

Numerous other reports of serious inroads upon herons and marsh-nesting birds have been received from the South Atlantic coastal plain, but as the observers of such occurrences seldom fail to differentiate between the two species of crows inhabiting this area, these citations are omitted.

From undeniable evidence furnished by stomach analysis, together with corroborative notes obtained from a multitude of reliable observers, it must be concluded that the destruction of other native birds and their eggs by the crow is a noxious trait of no small importance. Though all these species had been able to withstand this natural drain upon their numbers while under primitive environment, the many added taxes laid upon them by modern conditions, due to various agricultural activities, the draining of marshlands, the cutting of timber tracts wherein they had formerly nested, and the reduction of their numbers by hunting, have placed these birds in a disadvantageous position to resist the attack of their corvine neighbors.

The one circumstance which mitigates this evil is the fact that most of the depredations upon eggs and very young birds are committed during the breeding season of the crow, which is early enough to permit practically all the birds suffering losses to raise a second brood at a time when they need fear little from crows. This, no doubt, is just what takes place in many suburban districts and in breeding grounds of waterfowl, where every year crows secure much food for their young, yet the species preyed upon are seldom exterminated. There can be no question, though, that in public parks, in the vicinity of game farms, on game preserves, or other areas where it is desirable to foster certain species in numbers abnormal to the

allotment decreed by nature the crow must be held in check, and in some sections a substantial reduction in its numbers is a prerequisite to success in such enterprises. Grouse and quail are able to hold their own if given sufficient cover.

POULTRY AND THEIR EGGS.

Next to the pulling of sprouting corn, the destruction of poultry and their eggs is the phase of the crow's life habits that is brought closest to the attention of farmers generally. Though many extensive raisers of poultry have had little or no complaint to enter against the crow on this score, the frequency of occurrence and severity of damage on other farms indicate that the capabilities of the crow in this direction are too important to be overlooked. Judging from replies to letters of inquiry, there appear to be two areas in which this trait is developed to a higher degree than in others. In New York and Pennsylvania in the East and in Illinois and Indiana in the Middle West crows seem to be somewhat more addicted to the habit of destroying poultry and eggs than in surrounding districts. Ofttimes reports of striking similarity have come from localities widely separated, while circumstances diametrically opposite have occurred on neighboring farms. This fact, established by evidence from numerous able observers, indicates that the destruction of domestic fowls is a loss governed largely by local conditions, as the proximity of crows' nests, the presence of young crows, and the accessibility of poultry and their eggs. That this obnoxious trait is developed to an unusual degree in certain individual crows is also apparent. It was, in fact, the opinion of 121 observers out of 174 who expressed themselves on the subject that the poultry-molesting habit is one mainly of individuals, and that killing the comparatively few guilty of such misdeeds would practically prevent further similar trouble.

As in the consumption of wild birds and their eggs, domestic fowls, their young, and their eggs were shown by stomach analysis to constitute but a small portion of the bulk of the food—only 0.57 per cent. Such food was most important to the crow in May and June, when 1.49 and 1.33 per cent, respectively, was consumed. The next greatest proportion, 1.26 per cent, was eaten in November. In no other month did such food total as much as 1 per cent, and in August and October it was altogether lacking. Remains of chickens were present in 29 of the 1,340 stomachs, an average of 1 in about every 46. Eggs were eaten more frequently, being found in 35, an average of 1 in about every 38. Since in one stomach both a chicken and an egg were found, the frequency of depredations of adult crows on the barnyard, as determined by these stomachs, may be represented by the ratio of 63 out of 1,340, or about 1 in every 21, a lower ratio than

is recorded for such food in the stomachs of nestling crows (see page 65). In a few instances accurate determination could not be made, the remains being indistinguishable from those of wild birds. Most of the depredations on poultry are committed during the crow's breeding season, May and June. Over half the records of such feeding were secured from material collected in these two months, 21 in May and 11 in June. From the fact that 12 of the 127 stomachs collected in January contained poultry or their eggs, it would seem that a portion, at least, of such food should be classed as carrion.

The mentioning of a few occurrences of trouble experienced by poultry raisers will indicate the gravity of the issue and show the extent to which crows may conduct their operations under favorable conditions. Dr. Leon J. Cole gives, in his report[1] of investigations regarding depredations of the crow, the following two cases:

> The first of these was reported by Dr. V. L. Leighton, who has an extensive poultry plant not more than a half mile from the Experiment Station in Kingston. * * * He was troubled most seriously from about April 1 to July 10. This is just the season during which the crows are raising their young and the young are learning to forage for themselves. Dr. Leighton estimates that during this period he lost, from the depredations of the crows alone, in the neighborhood of 100 chickens, which was about 25 per cent of those hatched and not lost from other causes. All sizes were taken, from the time they were just hatched until they were a pound in weight. The larger chicks the crows killed and ate where they caught them, but the smaller ones they carried away in their beaks. Various efforts were made to keep the crows away, most of which were ineffectual. * * *
>
> The other instances * * * occurred near Cumberland Hill, in the northern part of the State. This was on the farm of Mr. E. E. Church, who was attempting to raise ducks on a suitable pond not a great distance from his house. The first lot hatched consisted of 135 ducklings; later in the season there remained of these but 14. In a later lot he had 70 ducklings and saved only 13 of them. The loss of nearly 87 per cent he attributes almost wholly to crows.

In a report similar to numerous others reaching the Biological Survey, G. S. Baker, of Rehoboth, Mass., states:

> Last spring I lost about 40 Rhode Island red chickens in 3 or 4 days. When the loss was discovered, a watch was kept and a crow was seen to come from a pine grove, take a chicken, and come back in 10 to 15 minutes for another. This crow was promptly shot and no more chickens were taken. (1912.)

Dr. Raymond Pearl, biologist at the Maine Agricultural Experiment Station, at Orono, explains that even less drastic methods have protected the poultry at the station:

> Crows are by far the most destructive enemies of poultry in the vicinity. They kill chickens up to and exceeding their own size. This past season we

[1] Cole, Leon J., The Crow as a Menace to Poultry Raising: Rhode Island Agr. Exp. Sta., 21st Ann. Rept., 1908, pp. 314–315.

were obliged to string the top of our poultry range with binder twine (strands 2 feet apart), the strands being stretched from division fence to division fence. In no other way were we able to stop the crows killing chickens. (1912.)

As the majority of reports give evidence that the poultry-stealing habit is one of individuals, it appears that combative and protective measures may be employed with success. The shooting of the particular marauders has in most cases put a stop to the trouble. Where losses to young poultry and eggs were at all severe, the use of wire netting to cover yards containing chicks and the provision of proper houses for nests have been effective, and the investment has soon paid for itself by the absolute protection afforded. The destruction of a near-by nest frequently prevents further loss to poultry, and crows may be retained throughout the general area to render good service to the farmer.

For additional control measures see pages 73–80.

SMALL MAMMALS.

In the destruction of injurious mammals the crow does work seldom recognized by the average farmer. While individually it may not be so aggressive in its pursuit of a victim as some of the birds of prey, the crow makes up such deficiencies by its greater numbers. The persistence of a squad of the black fellows mobbing a frightened cottontail rabbit or patiently searching grass hummocks for nests of mice early in spring is distinctly corvine. Stomach analysis gives ample proof of this trait, and, while specific identifications can not be made in most cases, the fact that mammals have been eaten is readily proved. Difficulties arise, however, in the distinction between mammal remains eaten as carrion and those secured alive. In identifying carrion among the remains of small mammals the writer relied entirely on the character of the associated insect remains. Necrophagous insects, as Silphidæ among beetles and the larvæ and puparia of blow flies, most frequently supplied this evidence.

Mammals comprised 1.64 per cent of the yearly food of the adult crows examined and were eaten in every month. The greatest consumption was in April, when such food totaled 4.10 per cent of the diet. In May 3.24 per cent was recorded; in March, 2.77; and in July, 2.60. In all other months the percentage was less than 2, being practically nothing (0.05 per cent) in September. Mammals occurred in 134 of the 1,340 stomachs, an average of 1 in every 10. Of these remains, injurious rodents formed the major portion. These pests were identified in 82 of the 134 stomachs in which mammals were present and doubtless occurred in many others where accurate determination could not be made. In bulk they formed approximately three-fourths of the mammal food, a yearly percentage of 1.22 being

recorded. March to July, inclusive, is the time of year when the greater part of this food is eaten, the maximum quantity (2.65 per cent) being taken in May.

Cottontail rabbits (*Sylvilagus* spp.), especially the young, were the rodents most frequently taken by adult crows, being found in 21 stomachs. It is doubtful whether crows during the breeding season play a less important part in the control of these animals than do any of the birds of prey. In areas where cottontails are plentiful they form an important part of the food of nestling crows (see page 66) and, quite naturally, the parent birds subsist on much the same fare. This food habit appears to be universal, records coming from all parts of the country. In four instances cottontails formed over half the stomach contents.

The following account of an attack by a crow upon a cottontail is given by Prof. W. B. Barrows:[1]

> On one occasion the writer saw a tragedy of this kind while driving along a Maryland road in June. A crow suddenly sailed over the fence and alighted in the road about 100 yards ahead of the horse. As he lit, he struck savagely with his bill at some dark object on the ground which tried to escape by jumping from side to side, but the crow followed each motion, striking quickly and heavily each time until the animal lay quiet, when, after a thorough pounding, the bird prepared to tear his quarry to pieces. Alarmed by the near approach of the wagon, he seized his prey in his bill and flew heavily over the bushes which fringed the road. Creeping to the fence I was able to identify the victim as a young rabbit, and subsequently found its tracks in the road at the point where the crow had attacked it. My companion said that usually he had seen young rabbits at this place in the road for a week past, but this was the first time he had seen one attacked by a crow.

Of the smaller rodents, meadow mice (*Microtus*) are the favorite food of the crow. They were identified in 20 of the 1,340 stomachs, in some of which they constituted a substantial portion of the diet. In one stomach, collected in New York in March, a meadow mouse made up 87 per cent of the contents; in another from the same State two individuals composed 38 per cent of the food; and in 5 others such rodents formed over three-fifths of the diet. Remains of white-footed mice (*Peromyscus*) were present in 5 stomachs, in one of which they amounted to 60 per cent of the contents. House mice (*Mus musculus*) were eaten by 5 crows. A brown rat (*Rattus norvegicus*) was captured by one. Four of five crows collected in Louisiana in January had fed on apparently more than one cotton rat (*Sigmodon hispidus*). The birds were secured at the same time and place and all probably were engaged in the same hunt. A harvest mouse (*Reithrodontomys*) and a pocket gopher (*Thomomys*) also were found in separate stomachs.

[1] Barrows, W. B., The Common Crow of the United States: U. S. Dept. Agr., Div. Ornithol. and Mamm., Bull. No. 6, pp. 31–32, 1895.

A few other mammals were identified, but they form a negligible portion of the adult crow's food. One bird collected in Wisconsin in May had eaten a short-tailed shrew (*Blarina brevicauda*) which practically filled the stomach. Two others secured in Maryland also had fed on shrews. Moles (*Scalopus*) were found in two stomachs, and a weasel (*Putorius*) and bat in one each. A tooth of a house cat was discovered in one stomach but was classed as carrion.

It is evident that the crow's destruction of mammals must be construed as a distinctly beneficial trait. Its greatest activities along this line are directed against rodents, in the control of which it well supplements the good work of hawks and owls, which unfortunately are now much too scarce in some sections.

ANNOYANCE TO LIVE STOCK.

The crow is accused of molesting and in some instances actually killing live stock, as young lambs and swine, and no doubt in some cases he is guilty. On this habit stomach examination sheds no light, but in view of complaints that have reached the Biological Survey it can not pass without comment, although these complaints are isolated and few in number and doubtless comparatively little aggregate loss has been suffered.

Mrs. Emma E. Drew, of Burlington, Vt., writing under date of January 4, 1912, says that in the country where sheep and lambs are out in the fields, crows sometimes swoop down on to young lambs and peck out their eyes; and that farmers in Au Sable Forks and Jay, N. Y., complained bitterly of the crows in this respect.

W. L. McAtee, of the Biological Survey, has informed the writer that, on G. G. Hammond's farm, Squibnocket, Martha's Vineyard, crows developed a habit of killing young merino lambs by pecking into the brains, which, with the eyes, were eaten. More than 50 lambs were killed in 1908. A bounty of 50 cents apiece was then offered and resulted in the destruction of about 40 birds. There has been no trouble since, and the normal number of lambs was reared the following year.

CARRION.

It is often difficult to determine the origin of such animal matter as flesh and bone fragments found in stomachs of crows. This may have been carrion or it may have been torn from the body of an animal killed by the bird itself. It frequently happens, however, that the stomach also contains insect remains, as carrion beetles (Silphidæ), short-winged scavenger beetles (Staphylinidæ), tumblebugs (*Canthon*), or scavenger flies and their larvæ and puparia, which furnish strong circumstantial evidence of the character of

the fleshy food eaten. In examining the stomachs every possible effort was made to determine the nature of this animal food. Error may have crept in in some instances, but a sufficient number of accurate identifications of carrion were made to warrant the assertion that crows readily consume such food at any time of the year and, when winter deprives them of much of their customary food, they will subsist extensively upon it.

The stomachs of adult crows examined revealed a yearly percentage of carrion of 2.58. This consisted of remains of small mammals, some chickens, fish, pieces of flesh and bone torn from larger carcasses, horse hair, hog bristles, and the like. It is highly probable that a large portion of the fish remains mentioned on page 27 also should be classed as carrion. January was the month of greatest consumption when such matter constituted nearly 9 per cent of the food. The other months were varyingly represented: April with 5.24, February, March, May, and September with from 2 to 3, and the remaining months with less percentages, down to July, which had only 0.29. In general these figures showed a greater consumption of carrion during the colder months.

Field observations indicate the extent to which these birds will sometimes subsist on offal, and numerous instances are on record of their rendering valuable service as scavengers. Dr. S. D. Judd, in writing of his experience with these birds in Maryland, said:[1]

> Crows and buzzards are valuable scavengers of dead fish cast up at low tide during the last of April and the first of May, when the fishing season is at its height. These fish are small, principally sunfish, white perch, and shad that were fatally injured by nets. Observations on May 5, 1901, showed the whole river front of the farm strewn with decaying fish, which gave out such a stench that one could not sit comfortably within several hundred yards of the beach. Some 40 buzzards were feeding on the carrion all day. On close inspection they were seen to be selecting that which was most badly decomposed. Crows in almost as large numbers and several crow blackbirds were also feeding, but they commonly took that which was less decayed. Several crows came repeatedly to the shore of lot 1, picked up fish, and carried them to their nests in the woods. By abating this nuisance crows and buzzards do a service that is appreciated by the occupants of the farmhouse.

P. S. Farnham, of Owego, N. Y., has written to the Biological Survey, stating—

> From pollution or other cause a great many fish die during the summer in the Susquehanna River here. The crow keeps these dead fish fairly well picked up. During a rise in the river this last summer I sat upon the banks near Campville and watched the crows. The dead fish were floating down and as soon as a crow saw one he would fly out, pick up the fish, take it ashore, and eat it. (1911.)

[1] Judd, S. D., Birds of a Maryland Farm: Bull. 17, Biological Survey, U. S. Dept. Agr., p. 53, 1902.

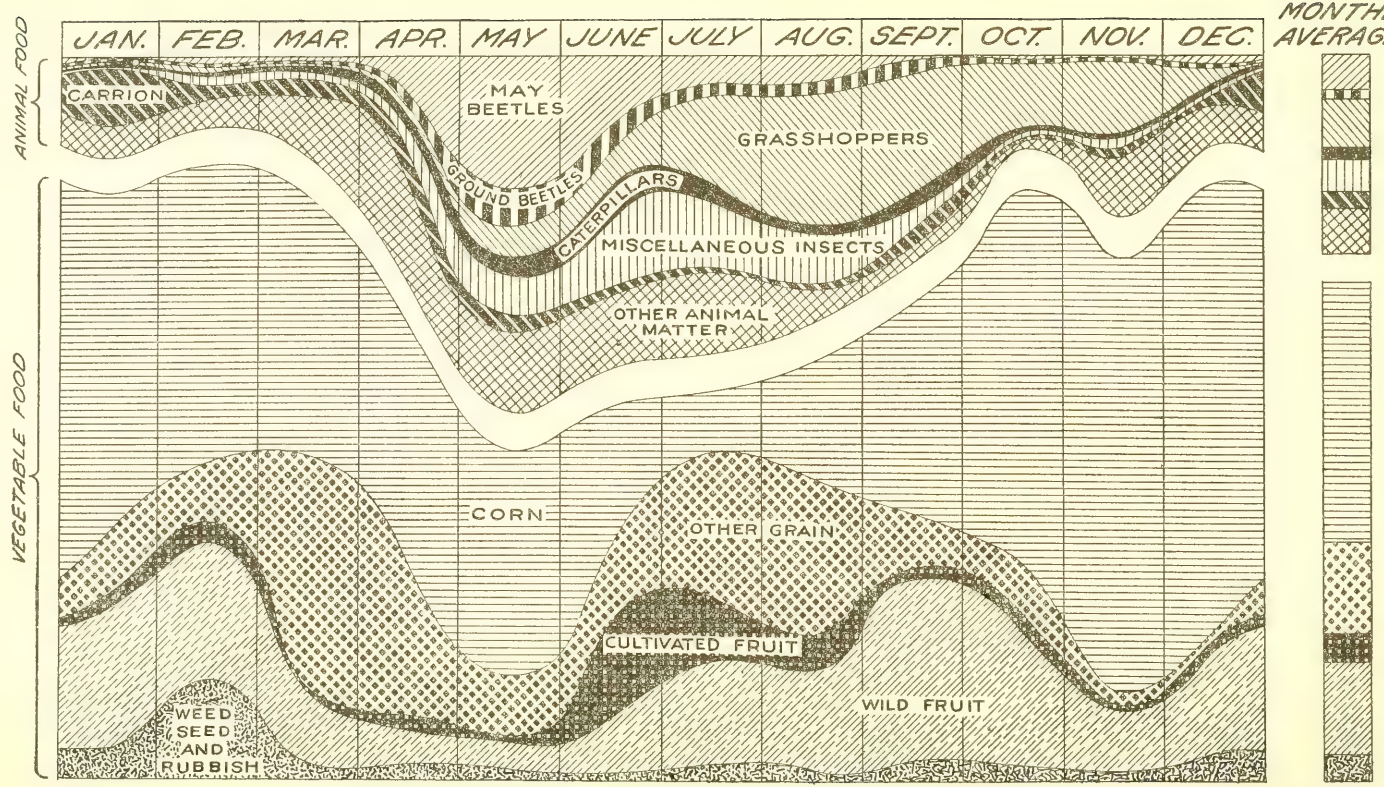

FIG. 2.—Food of adult crows. Showing the varying quantities of the principal items from month to month, and the relative monthly average of each item. In Table II, page 43, is presented the same information in percentages.

Regarding the winter feeding habits of these birds in the vicinity of Geneva, N. Y., Prof. E. H. Eaton, of Hobart College, reports that in the winter of 1911–12 there were hundreds of dead ducks on the ice of Seneca Lake, which was frozen for the fourth time in its history. These attracted considerable flights of crows. The crows fed also on the garbage which was carried from the city of Geneva in various directions to the north and northeast, and they followed the line of the Seneca River, evidently attracted by dead fish, crawfish, frogs, and other creatures which they were able to pick up along the margin.

Slaughter houses, fish and lobster canneries, and the mouths of sewers are favorite rendezvous of crows. Here these birds are assured an ample supply of food even in severe weather. Under such conditions their presence is highly desirable.

Vegetable Food.

Examination of stomachs has shown that the crow is largely a vegetarian. Vegetable food formed 71.86 per cent of the annual diet of the adult crows available for this investigation. In only one month, May, did it constitute less than half the total, in which case 47.56 per cent was recorded. In the months following, a uniform increase was noted. June was represented by 53.02 per cent; July by 55.72; August, 60.60; September, 67.68; and October, 85.71. In November a decrease occurred (81.26), but in the winter months, December, January, and February, very large quantities again were eaten, represented by the percentages of 86.82, 85.06, and 89.03, respectively, the last being the largest quantity recorded for any month. The vegetable portion decreased rapidly in March (83.95) and April (65.91). Figure 2, on page 42, represents diagrammatically the variations in the vegetable as well as the animal food eaten in the different months.

Table II.—*Monthly percentages of the principal food items of the adult crow.*

Kind of food.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average
May beetles, etc	0.18	1.19	1.04	4.98	20.79	10.06	4.47	5.26	0.91	0.54	0.77	1.17	4.28
Ground beetles	.07	.10	.26	2.30	5.54	3.24	2.13	1.76	2.31	.14	.74	.19	1.56
Grasshoppers	.51	1.14	.56	1.84	4.29	5.83	14.04	19.14	19.24	8.68	10.73	2.07	7.34
Caterpillars	.18	.41	1.36	1.13	2.71	6.41	1.95	.62	2.12	1.19	.30	.39	1.56
Miscellaneous insects	.35	2.01	1.36	4.47	6.44	10.41	11.26	8.29	3.06	.96	1.62	.67	4.23
Carrion	8.95	2.45	2.66	5.24	2.13	1.48	.29	.95	2.69	.32	1.44	2.37	2.58
Other miscellaneous animal matter	4.70	3.67	8.81	14.13	10.56	9.55	10.14	3.38	1.99	2.46	3.14	6.32	6.57
Corn	51.95	43.19	36.85	35.28	33.26	20.53	9.13	17.96	29.60	54.33	63.93	65.00	38.42
Other grain	7.00	9.74	34.22	20.90	8.43	10.20	20.22	22.80	8.33	7.08	2.67	.89	12.70
Cultivated fruit	2.55	3.42	.26	2.74	.91	14.12	9.31	5.79	1.66	2.40	.07	1.36	3.74
Wild fruit	19.76	19.57	10.65	5.06	3.49	7.28	14.05	13.67	25.82	20.50	12.94	14.75	13.96
Weed seeds and rubbish	3.80	13.11	1.97	1.93	1.45	.89	3.01	.38	2.27	1.40	1.65	4.82	3.06

CORN.

Complaints most frequently heard against the crow concern its depredations on corn. Injury to this crop may be either to the sprouting grain, to the grain when in "the milk," or "roasting-ear," stage, or when the ripened corn has been stacked in shocks. Of the three, the last form of injury appears to be the least serious. The pulling of sprouting corn, fortunately, may be largely prevented by the use of deterrents (see p. 74), but the damage to the grain when in the "roasting-ear" stage constitutes the most vexatious form of damage of which the crow is guilty. This results not so much from the grain the crow actually eats, as from the subsequent injury caused by water entering the ears from which the husks have been partially torn.

Stomach analysis has shown that corn is without question the staple article of diet of the adult crow, and even the older nestlings are fed a considerable quantity (see p. 67). This grain constituted 38.42 per cent of the yearly food of the 1,340 adult crows examined. In July, the month in which practically no growing corn is available, the monthly percentage recorded reached its lowest point, 9.13. Late in August corn in the "roasting-ear" stage becomes accessible over much of the area in which crows' stomachs were collected, a fact shown by its increased proportion in the food, 17.96 per cent. September is represented by an even greater quantity, 29.60 per cent, much of which was doubtless pilfered from the ripening crop. In October corn exceeds all other foods combined (54.33 per cent), but the harvest, with its attendant waste of grain, may account for a portion. Late November and all of December, January, and February are times of dire privation for the crow and the fact that it can find in these four months subsistence mainly from waste corn, sufficient to supply 63.93, 65.00, 51.95, and 43.19 per cent, respectively, of its food, speaks well for the persistence and frugality of the bird. In March and April less quantities are taken (36.85 and 35.28 per cent, respectively), and these also may be relegated largely to the category of waste grain. Some of the corn eaten in April may have been from the sprouting crop, especially in the case of crows collected in the Southern States. Had a greater series of stomachs been collected in the South, more consideration would have to be given to the earlier planting and sprouting time in that region. In May, however, when corn formed a substantial portion of the diet (33.26 per cent), a considerable part was doubtless secured from newly planted fields. But when it is considered that in June corn still formed over a fifth (20.53 per cent) of the food, at a time when comparatively little can be obtained in this way and when even less

waste grain is available than in the preceding month, it is apparent that even in sprouting time at least half the corn eaten by the crow probably represents no loss to the farmer.

An idea of the corn-eating proclivities of the crow at various times of the year may be gained also by noting the frequency with which such food was eaten, as presented in Table III.

TABLE III.—*Relation of the number of stomachs containing corn to the total number examined.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Total number of stomachs	127	69	132	89	197	203	100	42	75	177	57	72	1,340
Number of stomachs containing corn	97	43	86	73	112	90	21	15	39	137	49	62	824
Percentage containing corn	76.37	69.35	65.15	82.00	59.89	44.33.	21.00	35.23	52.00	77.40	85.96	86.11	61.49

It will be seen by comparison with Table II (p. 43) that, with the exception of April, the story of the corn-eating habits of the crow, as determined by the frequency of feeding, is almost identical with that revealed by the bulk of corn taken. July is the month represented by the lowest percentage. The ratio then increases uniformly until the last of December, after which a regular decrease is noted, except for April, as previously cited, when an unusually large proportion of the birds had fed on corn in small quantities.

Individual stomachs in which very high percentages of corn were recorded were found frequently in the material examined. Fifty of the 1,340 stomachs of adults were filled with this grain exclusively, 97 contained from 95 to 99 per cent, and 59 contained over 90 per cent. Most of these large percentages were recorded in October, when 56 of 177 crows had subsisted on corn to the extent of more than 90 per cent of their food.

Tabulation of the results of stomach analysis under the separate States in which the material was collected revealed little of special interest. The frequency of the corn-eating habit could be satisfactorily determined in only a few States because of insufficient material. Of the 198 adult crows collected in Maryland 147 had fed on corn; from New Jersey, 134 out of 161 had eaten such food; and from New York, 41 out of 122. An example of the unsatisfactory results obtained from a few stomachs collected at the same time and in identically the same environment is shown by a series of 48 crows collected in North Carolina in January. Forty-five of these had fed on corn, which comprised nearly 65 per cent of the food. As this constituted all the material from this State, it would be manifestly wrong to let this evidence stand as the sole basis for determining the relation of the crow to the corn crop in North Carolina.

A perusal of many replies to inquiries sent to various parts of the country in 1911 and 1912 shows some diversity of opinion even in restricted localities, but by a tabulation of the data under the various States a very good idea of opinions in the different parts of the country has been obtained.

By far the severest criticism of the corn-eating proclivities of the crow comes from the Northeastern States, including Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and West Virginia. These States, according to the statistics of 1912, devoted about one twenty-fifth of their total area to the cultivation of corn. On the other hand, comparatively little complaint was heard from the farmers of the upper Mississippi Valley, in the States of Ohio, Indiana, Illinois, Michigan, Wisconsin, Iowa, Missouri, Nebraska, and Kansas. Of these States Ohio, Indiana, and Wisconsin appear to have the greatest grievance against the crow, though even here, with the possible exception of Indiana, the consensus of opinion was that damage was not serious. In this part of the upper Mississippi River valley nearly one-sixth of the total area (or four times the ratio for the Northeastern States) was devoted to corn.

Along with these seemingly irreconcilable figures comes the fact that, notwithstanding the drains which the crow is supposed to make on the corn crop, the farmer of the Northeast produced nearly as many bushels to the acre as his western competitor. As the crow is practically as numerous over much of this western area during spring and summer as in the Eastern States, one is compelled to look further for the cause of its being so much more unwelcome to the corn raisers of the East. A comparison of conditions prevalent about the average cornfield of the East and the West may suggest the solution. The very fact that the ratio of the corn acreage to the total area of the West is approximately four times that of the East indicates the existence of much larger fields. The comparative scarcity of timber suitable for nesting sites in some sections of this western country confines the crows during sprouting time to the vicinity of the limited wooded areas, leaving extensive corn lands wholly free from their attack, while in the East the smaller fields with the intervening wood lots produce conditions admirably adapted to the needs of these birds. Then, too, the existence of more intensive farm operations on the smaller fields of the East accounts in large measure for the increased yield per acre, and at the same time gives reasons for the unfavorable opinion regarding this bird. Losses, though even slight, are likely to attract the attention of the assiduous cultivator of a small crop, while damage, oftentimes extensive, frequently will be overlooked by the owner of

large fields, especially when the actual cause of the injury has escaped notice.

Dr. S. D. Judd, relating his personal experience with corn-pulling crows, has said:[1]

> The crow is by all odds the worst pilferer of the cornfield. * * * In 1899 the replanting was more extensive than usual, requiring on the 39-acre field 1 bushel 2½ pecks, 46 per cent of the 3½ bushels originally planted. This unusual ratio was probably caused by the failure of the cherry crop.

L. E. Wilcox, of Butterfield, Ark., complains that—

> in this immediate neighborhood we have been overrun with crows. They have destroyed fully 10 per cent of the corn crop by picking into the ears during the roasting-ear stage, eating some ears nearly up; and rains afterwards rotted the rest of the ear. (1912.)

From New Jersey comes this account submitted by Justus von Lengerke:

> The damage done by crows to the little mountain farmer by pulling seed and sprouting corn is considerable, and total crops have been ruined thereby, while others are badly damaged, necessitating a partial replanting, when the corn will mature at different periods. They also do some damage to corn when in the shock. (1911.)

E. P. Robinson, of Packer, Conn., states that the crow does great damage by pulling corn when it first appears above ground and until it is 10 inches high, and again in August and September before cutting. He also says that it damages corn fully $5 an acre in eastern Connecticut each year, and that some fields are wholly destroyed.

Drawing conclusions, then, from both stomach analysis and field observations, it is evident that the crow is accountable for considerable direct damage to the corn crop. While careful interpretation of the results of laboratory investigation reveals the fact that this grain, taken when sprouting, when in the "roasting-ear" stage, or before harvest, forms a relatively small portion of the crow's annual supply of corn, such circumstances can not mitigate the evil done. Much may be done, however, by treating the seed grain with deterrents to make the sprouting crop largely immune to attack; frightening devices help some while the grain is ripening (see p. 74); and prompt harvesting and proper housing of the grain will prevent much of the loss at present suffered, especially in some of the Southern States where corn in shocks frequently is left standing all winter, tempting provender for roving bands of underfed crows.

OTHER GRAIN.

Grain other than corn formed 12.70 per cent of the food of adult crows. Wheat, oats, and buckwheat constituted practically all of

[1] Judd, S. D., Birds of a Maryland Farm: Bull. 17, Biological Survey, U. S. Dept. Agr., p. 65, 1902.

this, the first being most often eaten. Tabulation of the monthly percentages of these grains reveals two periods of great consumption. The high tide of one is reached in March, when they formed over a third (34.22 per cent) of the diet. From this point a decrease through April (20.90 per cent) to May (8.43 per cent) was noted, after which the monthly averages again increase. In June small grains formed 10.20 per cent of the food; in July, 20.22; and in August, 22.80, the second period of great consumption. A marked decrease occurs in September (8.33 per cent); October is represented by 7.08; November, 2.67; and December, 0.89, the minimum monthly quantity recorded. In January and February these grains formed 7.00 and 9.74 per cent, respectively, of the food. Inasmuch as wheat predominated among the smaller grains, it is possible that the two maximum periods (March–April and July–August) are indicative of the sowing and sprouting season in spring, and of the harvest of the crop late in summer.

Wheat.

Wheat was present in 227 of the 1,340 stomachs of adult crows, an average of about 1 in every 6. Local influences, especially the absence of corn, appear to determine the extent of the crow's depredations on this crop. Stomachs collected in the Northwest illustrate this point. Four crows collected at Corvallis, Oreg., in January, had fed on wheat exclusively, over 237 kernels being counted in their stomachs. Three of five stomachs secured in Saskatchewan in April were practically filled with this grain. All of a series of 10 crows from Manitoba, also taken in April, had fed on wheat, which comprised over two-thirds (68.9 per cent) of their food. In the stomachs of six others, secured in Manitoba in the month following, it formed over 40 per cent of the contents.

When attacks upon wheat are made in sowing or sprouting time, the depredations of even a single crow, limited only by a most ample gizzard, may be of considerable consequence. Two birds collected in Manitoba in April had eaten 140 and 133 kernels, respectively. Another taken in the same place in May had devoured 86, while one collected in British Columbia, in March, had made away with 54 kernels of wheat and 7 of oats. At harvest time and after, a large part of the wheat eaten by crows may well be classed as waste, involving no loss to the farmer. Birds collected in wheat-raising areas at this time of year usually were well fed. Six stomachs contained 135, 120, 91, 90, 65, and 60 kernels respectively, and in several others over 25 kernels were noted.

Evidence of the wheat-eating habits of the crow revealed by stomach analysis has been corroborated by field observation. Dr.

H. A. Surface, former State Economic Zoologist of Pennsylvania, reported the following:

> I note for example that crows have done a great deal of damage on adjoining wheat fields during the winter time by eating almost every leaf of the wheat that was above the ground or snow. One wheat field on our place, which should be quite green, is now about bare. (1912.)

Henry W. Marsden, of San Diego, Cal., complains of the destruction of wheat when in the shock (1912). Edwin Loreman, of Morrison, Ill., reports damage to both wheat and oats, which are scratched out at sprouting time (1912); and H. Martyn Micklem, of Shipman, Va., writes that "crows eat quantities of seed wheat and seed oats when the grain is imperfectly covered. Most writers appear to overlook this."

Oats.

Oats occurred in 114 of the 1,340 stomachs of adult crows, an average of about 1 in every 12, or half the number in which wheat was found. When it is considered that oats are readily available at all times of year in horse droppings, from which also the birds may secure coprophagous insects, the quantity of this grain in their diet need not greatly concern the farmer. Only occasional reports of crows attacking the sprouting crop have come to hand. The habit must be considered one of the minor offenses of the crow, from which individual farmers here and there suffer.

Other small grains.

Buckwheat was found in 107 stomachs, but if a larger proportion of the birds had been collected in areas where this grain is extensively grown, it probably would have been found in a far greater number of stomachs. The seeds of Polygonaceæ are a favorite food of birds generally, so it would not be surprising to find that the large meaty kernels of buckwheat are an even greater attraction to crows than stomach analysis seems to indicate. That buckwheat is eagerly eaten was noted especially in a series of 45 crows collected in New Jersey in March; this was prior to the sowing time, so that the buckwheat eaten must have been either waste from the preceding year's crop or from volunteer plants along roadsides. Thirty-eight of these birds had eaten buckwheat, which formed 66 per cent of their food, and 11 of them had subsisted exclusively upon it. Another series of 100 birds collected at the same place during October revealed but little consumption of buckwheat. This grain, eaten by only 23 of these birds, constituted 6.15 per cent of their diet. The only report of damage to this crop is from D. W. Southard, who complains that

crows inflict considerable injury to buckwheat in the vicinity of Gilboa, N. Y.

Injury to kafir corn (sorghum) in autumn has been reported from Kansas and Oklahoma. These depredations usually have been in the vicinity of roosts, where, during the roosting period, many thousands of crows are congregated and day after day feed over a comparatively small area. Stomach analysis sheds little light on this habit, as only 5 stomachs contained the grain, but an idea of the severity of the attacks may be gained from the following communication from George W. Seigel, of Chetopa, Kans.:

> As to kafir corn, which is to become a staple crop here, they [crows] simply eat all the grain. The kafir fodder, which is a fine stover feed, is of such a juicy nature that it will not stand stacking. When the crows were taking ours so persistently in the shock we hauled it in and stacked it in the barn. This molded so badly that the fodder was not fit to use and what was stacked outdoors rotted.

F. F. Crevecoeur, of Onaga, Kans., reports that crows damaged about 50 bushels of kafir corn on one farm near a crow roost.

Rye was found in six stomachs.

MISCELLANEOUS CROPS.

The crow is guilty of damage to many crops which, from the nature of their vegetable composition, can not be detected or accurately separated from other items of the stomach contents. Among these may be mentioned numerous fleshy fruits, as apples, pears, and prunes; the rind and pulp of melons; the meat of nuts which have been partly digested and fail to have fragments of the shell associated; and the fragmentary remains of some tubers. Though many of these have been satisfactorily identified in stomachs, the presence of small quantities intimately mixed with other material is probably many times overlooked. Here again conclusions must be based to a certain extent on the evidence furnished by field observers.

Though 186 of the 1,340 adult crows had fed on what appeared to be cultivated fruit, 47 of these records were made from the 1st of November to the end of May, when the fruit eaten must necessarily have been waste. Frozen apples or inferior pumpkins left in the fields after harvest are highly prized by foraging crows late in winter and apparently are sources from which some of the birds examined had secured food. The seeds of certain cultivated fruits, as blackberries, mulberries, grapes, and strawberries, are so similar in appearance to wild varieties growing in the same areas and ripening at the same time, that it was impossible satisfactorily to classify many of them. It is highly probable that many of the fruits supposed to have been pilfered from the farmer's crop really were secured from nature's ample supply. Evidence furnished by stomach analy-

sis indicates that grapes, strawberries, blackberries, raspberries, and apples are the fruits most often eaten. But probably next in importance to the destruction of corn and other grain by crows is the damage to melons, and upon this stomach analysis sheds practically no light. Complaints of this kind have come from practically all of the Southern States, as well as from a few points in the North. The crow's work on a melon patch is of a most annoying and destructive character, the damage being in the form of holes pecked into the melons. Most of the punctures are small, and after eating a little of the pulp and seeds of one melon the bird proceeds to another, where it inflicts like injury. In this way a comparatively few birds may do extensive damage. The following account by Dr. S. D. Judd[1] will give some idea of the extent and nature of the losses suffered:

> The only fruit grown for market that suffered from the depredations of the native birds was the melon, and it was attacked by one species only—the crow. In numbers from three to four to a dozen at a time, crows began to injure melons about August 1 and continued for three weeks, attacking both watermelons and canteloupes, but preferring the former. Each crow would peck at a melon a dozen times or so and then pass on to another. If no protective measures had been taken, the crop would often have been a total loss, and, in spite of all efforts, from 5 to 20 per cent of the melons grown at all distant from buildings were punctured. (1895–1902.)

The injury to ripening apples is at times considerable and of a nature not easy to prevent, especially in large orchards. This fruit was identified in 10 stomachs. A letter from T. A. Farrand, of Eaton Rapids, Mich., in this connection, reads:

> The newest thing that I know about the crow and how destructive it can be in a short time was in an apple orchard of which I have control near Ann Arbor, Mich. A year ago last fall, when harvesting the apples in one end of the orchard, we noticed large numbers of crows in the other end when we came to work in the morning. After the second occurrence my curiosity was aroused and I went to investigate. I found bushels of very fine apples ruined by their pecking into them. One variety, "Jonathan," was their choice. It was the first instance that I ever heard of. It did not occur this year. (1912.)

Maj. Allan Brooks, of Okanogan Landing, British Columbia, adds the corroborative evidence that "crows at the coast (both species) also do great damage to ripe apples on the trees" (1912), and H. L. Felter, of Washta, Iowa, has written that "crows pick off apples apparently just to see them fall to the ground. One man thinks they picked off 100 bushels." (1911.)

Reports from time to time have been made of injury to potatoes, especially when sprouting. One instance was recorded a few years ago at Cape Ann, Mass., where a potato patch, newly planted, was attacked by crows. One side of the field had been ravaged by them,

[1] Birds of a Maryland Farm: Bull. 17, Biological Survey, U. S. Dept. Agr., p. 57, 1902.

the potatoes being left on the ground after they were dug up. The other side of the patch was "lined" with cotton string and two crows were shot and hung up there, but a week later all but a few of the seeds that were in hills beneath the string had been dug up.[1]

Complaints that the crow damages crops other than those mentioned have occasionally come to attention. Among these are peanuts, beans, peas, figs, oranges, grapes, cherries, and such marketable nuts as almonds, pecans, and chestnuts. Among these the most extensive damage appears to have been done to peanuts, pecans, and almonds.

One observer in South Carolina asserts that it was almost impossible to grow peanuts in his locality. George A. Blair, of Mulvane, Kans., while making certain inoculation experiments with peanuts, suffered severely from crows. He said:

I could not call this a test, as the crows practically ate up the crop. We were busy picking up apples and they took advantage of us and practically ruined the crop so that we could not dig the nuts. (1906.)

W. S. Cruzan, of Sulphur Springs, Tex., has said that—

they [crows] gather the pecan nuts and eat them, also storing them for future use. They will often fly from a pecan tree with nuts to a place on the prairie near some bushes or weeds, and deposit a little pile of nuts, often as much as a pint or more.[2]

D. D. Stone, of Oswego, N. Y., states that—

crows are great lovers of chestnuts and do lots of mischief in chestnut groves, stealing the nuts from the burrs that are open. They prefer to take them from the burrs, but sometimes alight on the ground for the fallen ones. A few miles south of here are many chestnut groves, and in fall the crows are more numerous there than here. (1911.)

At Davis, Cal., B. S. Brown reports that—

the greatest damage is done to the almonds. They [crows] pick the nuts off the trees and beat them against a rock or tree until they break open. At this time of the year (January) they are in the old orchards picking up the waste nuts. (1912.)

Concerning their depredations on peas, John H. McCluer, of Franklinville, N. Y., submitted the following:

The crows first begin on peas when the new pea in the pod is fairly well formed, say one-quarter grown, and continue until ripe enough for canning purposes. They eat pods and all in the young growths, but shell the pea as soon as the pod toughens a little. To my personal knowledge they have so attacked three fields lying on different farms, but so near together that it is possible if not probable the work was done by the same flock of crows. (1901.)

William L. Finley reports from Oregon that—

in the Willamette Valley the crow does considerable damage to the cherry crop, but the birds are easily frightened from the trees. If unmolested they will soon strip a tree. (1911.)

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[1] Forest and Stream, LVIII, p. 285, April 12, 1902.

[2] Bull. Wilson Orn. Chap. Agassiz Association, II, No. 5, p. 12, Mar. 15, 1895.

From Orlando, Fla., comes information contributed by D. J. Nicholson that "crows at times do immense damage to the oranges. This occurs in the winter when they congregate in bands of 50 to 100." (1911.)

Injury to these various crops is not so serious or extensive as that inflicted upon corn and other grain. Nevertheless damage is liable to occur at most unexpected times and upon crops difficult to protect. Such raids are most frequently made by a number of birds upon single exposed fields or orchards, and result in heavy losses to individual farmers. From their particularly annoying nature, these activities should be charged against the crow in a consideration of his economic worth, even though the aggregate damage throughout the country may not be great.

WILD FRUITS.

Under primeval conditions wild fruits doubtless formed over half the annual food of the crow. But the advent of man with his introduction of corn so greatly altered the relative availability of this natural food supply that at present it constitutes less than 14 per cent (13.96) of the bird's yearly sustenance. May is the month of least consumption, when it formed only 3.49 per cent of the food. From this point a gradual increase was noted until September, when over a fourth (25.82 per cent) of the bird's food was secured from natural sources. October was also well represented (20.50 per cent), but in November and December considerably less was eaten (12.94 and 14.75, respectively). In January and February apparently the diminution in the available supply of corn again compels the crow to resort to wild fruit. In each of these months it totaled nearly a fifth of the food (19.76 and 19.57 per cent, respectively). The reduction recorded in March (10.65) and April (5.06) is due to an increased supply of animal food which becomes available with the advent of warmer weather. Of the 1,340 adult crows examined 576 had fed on wild fruits.

Stomach analysis reveals the fact that mast, from a variety of sources, but mainly acorns and chestnuts, furnishes the main supply of vegetable food secured from natural sources. Such food was recorded in 293 stomachs. Various sumacs, both poisonous and nonpoisonous, are especially favorite items and constitute an important part of the crow's limited rations late in winter, when the supply of many other wild fruits has been exhausted. Seeds of nonpoisonous sumacs were found in 246 stomachs. Among these, those of smooth and dwarf sumac (*Rhus glabra* and *R. copallina*) seemed most popular. Poison ivy (*Rhus radicans*) occurred in 66 stomachs and poison oak (*Rhus vernix*) in 18. The consumption of the latter two noxious plants involves the crow rather unfavorably in the problem

of seed distribution, a discussion of which is presented on pages 68 to 71. The bayberry (*Myrica carolinensis*) and the wax myrtle (*M. cerifera*) furnish subsistence for many crows along the Atlantic coast, and in the southern part of this region the greenbrier (*Smilax* spp.), grapes (*Vitis* spp.), the Virginia creeper (*Parthenocissus quinquefolia*), sour gum (*Nyssa sylvatica*), and dogwoods (especially *Cornus florida*) are important food items. Wild cherries (especially *Prunus serotina* and *P. virginiana*) and plums present in 62 stomachs, strawberries in 50, and mulberries, blackberries, and raspberries in a fewer number were eaten during the rather brief fruiting seasons of these plants. The Juneberry (*Amelanchier* spp.) is a favorite food of the crows inhabiting parts of the northwest coast, though there are numerous records of such feeding in other regions as well. Blueberries (*Vaccinium* spp.) and elderberries (*Sambucus* spp.) must also be classed among the more important wild fruits upon which crows feed. Seeds of the following trees and shrubs also were taken from stomachs: Red cedar (*Juniperus virginiana*), beech (*Fagus americana*), hackberry (*Celtis* sp.), barberry (*Berberis* sp.), currants (*Ribes* sp.), haw (*Cratægus* sp.), holly (*Ilex opaca*), supple-jack (*Berchemia scandens*), buffaloberry (*Lepargyrea* spp.), and huckleberry (*Gaylussacia* sp.).

The mere consumption of wild fruit by the crow involves nothing of economic importance, since practically none of the embryos of the seeds are thus destroyed; but the fact that the crow, for that very reason, becomes an important distributor of certain noxious plants, necessitates a careful consideration of the bird's capabilities in this respect. (See pp. 68–71.)

GRASS AND WEED SEEDS.

Plants popularly classed as weeds are affected in no appreciable way by the seed-eating habits of the crow. Weed seeds formed only 1.36 per cent of the annual food of the 1,340 adult crows examined. That the percentage is even this high is explained by the fact that in February, when only 69 stomachs were available, several were practically filled with vegetable débris associated with a few weed seeds, all of which was classed under this head. This material would probably have been better designated as rubbish picked up unintentionally with carrion upon which also these birds were feeding. Thus interpreted, the weed seeds eaten would scarcely exceed half of 1 per cent of the yearly food.

Various knot weeds (*Polygonum* spp.) occur most frequently, and the seeds of the two foxtail grasses (*Chætochloa glauca* and *C. viridis*) scarcely less so. Seeds of ragweed (*Ambrosia artemisiæfolia*) are liable to be picked up at any time. The minute seeds of pigweed (*Amaranthus* and *Chenopodium*), so abundant in waste places, are so small that it is doubtful whether they are ever taken

intentionally. Pokeweed (*Phytolacca decandra*) was present in only 8 stomachs, but from the débris found at roosts in the vicinity of Washington, D. C., it is apparent that the seeds of this plant form an important part of the winter food of the crows of that region. Such noxious plants as poison ivy and poison oak are discussed under the heading "Wild Fruits," on page 53.

FOOD OF NESTLING CROWS.

For several reasons a correct understanding of the food habits of nestling crows is essential to a complete consideration of the economic status of the species. These young birds, which average approximately four to a brood, remain in the nest for about three weeks, during which time they consume an immense quantity of food. According to Forbush,[1] fully fledged young crows will eat daily a quantity equal to at least half their own weight, and doubtless in the earlier days of their existence this ratio is greatly exceeded. When a normal number of young are raised they will outnumber the adults nearly 2 to 1 throughout most of the United States during the month of May. This fact is especially important, inasmuch as the height of abundance occurs at the time of appearance of some of the most destructive insects, which, if unchecked, would lay heavy toll on the season's crops. Then, too, the nestling life of the young crow coincides with or slightly precedes that of many small insectivorous birds, upon the eggs and young of which it is sometimes fed. Poultry raisers can attribute most of their losses in eggs and young chicks to the zeal of parent crows in providing food for hungry young rather than to a desire to satisfy their own appetites, since this could be done more safely at a greater distance from the farmhouse. Growing crops, also, especially sprouting corn, are at a critical stage of development at this time, and, should these be selected as food for nestling crows, the damage would be of a most serious nature.

Fortunately an excellent series of stomachs, 778, is available for a consideration of the food of nestling crows. Of these, 47 were secured late in April, 653 in May, and 78 early in June. They were collected in 14 States, the District of Columbia, and Canada, the largest numbers being taken in Kansas, Missouri, Maryland, and the District of Columbia. The birds ranged in age from the blind and naked young of a day or two to the fully fledged bird weighing almost as much as its parents and capable of consuming considerably more food.

The elements of the diet of nestlings are essentially the same as those of adults, though the relative percentages differ considerably. The food habits of the nestlings themselves also vary from the period when, a day or two old, their tender-walled stomachs require such soft,

[1] Forbush, E. H., Useful Birds and Their Protection, p. 47, 1907.

digestible food as spiders and caterpillars, to the time when, fully fledged, they relish hard-shelled beetles, crustaceans, small mammals, and grain, a diet differing but slightly from that of the parents. The series of stomachs examined includes young of all ages, and, as the various stages of growth are about equally represented numerically, the percentages derived may be considered as approximately a true average for the nestling. A diagrammatic representation of the food of these young birds is presented in figure 3 and a tabular statement showing percentages is given in Table IV, below.

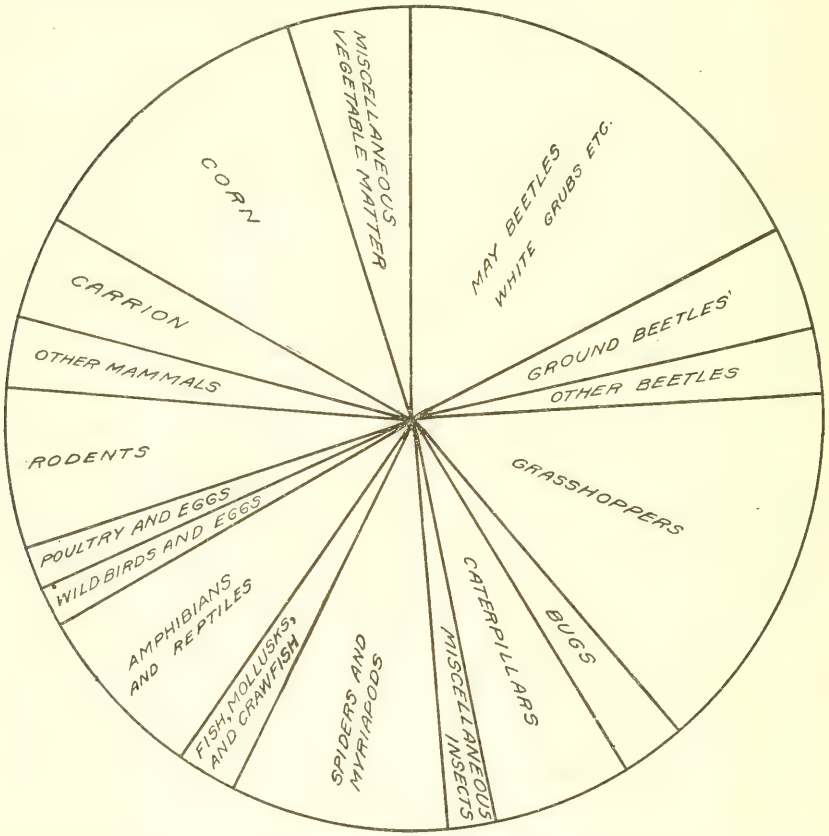

FIG. 3.—Food of nestling crows. The proportions of the various elements are represented by the relative sizes of the different sectors. Table IV presents the same information in percentages.

TABLE IV.—*Percentages of the principal food items of the nestling crow.*

May beetles.	Ground beetles.	Other beetles.	Grasshoppers.	Bugs.	Caterpillars.	Miscellaneous insects.	Spiders and myriapods.	Crawfish.	Fish and mollusks.	Amphibians and reptiles.	Wild birds and eggs.	Poultry and eggs.	Rodents.	Other mammals.	Carrion.	Corn.	Miscellaneous vegetable matter.
17.44	3.90	2.59	14.60	2.61	5.34	1.88	9.68	1.78	0.68	7.04	1.57	1.60	6.22	2.61	3.95	11.91	4 58

Animal Food.

INSECTS.

Animal food comprised 83.49 per cent of the diet of the nestling crows examined, insects forming the major portion, 48.36 per cent. Nearly half of this, 23.93 per cent, was composed of beetles, slightly less than the corresponding percentage in the diet of adults during May.

Coleoptera.

Scarabæidæ.—Scarabæid beetles, most of which were May beetles (*Phyllophaga*) were the most important coleopterous remains found in the nestlings' stomachs. In bulk these beetles and their larvæ, white grubs, formed 17.44 per cent of the food, about 3 per cent less than in the diet of the adults during the same period. While both in percentage of food and number of individuals eaten the adult crow consumes more May beetles than its young, the importance of such food eaten by the latter must not be overlooked. For instance, each one of a brood of three nestlings collected in Wisconsin had been fed entirely on these insects. Five young taken in the District of Columbia had subsisted to the extent of nearly three-fourths of their food on adult May beetles, an aggregate of about 70 individuals being consumed by the brood. Another hatch of three secured in Maryland had fed on them to an extent of 84, 98, and 80 per cent, respectively, of their food. Stomachs collected at Onaga, Kans., in May of 1913 and 1914, revealed the remains of these beetles and their larvæ in remarkably large numbers. A series (three broods) of 12 nestlings, three-fourths grown, had eaten a total of 301, an average of over 25 apiece, along with several *Euphoria*, *Phanæus*, *Canthon*, *Geotrupes*, and other scarabæids. One of these had eaten 53, the highest number of May beetles recorded for a young crow. Another group of 17 (four broods) had destroyed 344, an average of over 20 apiece. Six others (two broods) had made away with 135 beetles. Of a total of 359 stomachs of nestling crows collected at Onaga, Kans., in 1913 and 1914, 285 contained remains of May beetles or their larvæ. The 64 beetles eaten by a brood of three secured in Dallas County, Mo., are interesting in that they include no less than nine distinct species. Of the larvæ (white grubs), young crows eat a much larger proportion than do the parent birds, but in no case did the numbers eaten equal those of the adult beetles consumed. A brood of three partly feathered young secured in Kansas had eaten 34, 28, and 23 white grubs, respectively, two others had taken more than 20 apiece and six others more than 10 apiece.

Other phytophagous scarabæids similar to those eaten by the adults are also fed to the young (see p. 13). Euphorias were found

in numerous stomachs, in each of two instances 10 individuals being eaten. The carrot beetle (*Ligyrus gibbosus*) and others of the same genus occurred frequently in stomachs from Kansas and Missouri, though in no case in large numbers. June bugs (*Cotinis nitida*), vine chafers (*Anomala* spp.), goldsmith beetles (*Cotalpa lanigera*), and other related forms were found now and then in the nestling stomachs. The dung-inhabiting scarabæids (Laparosticti), are eaten by young crows frequently, though the small size of some, as *Aphodius*, prevents their forming an appreciable portion of the food. Tumblebugs (*Canthon* and *Geotrupes*) occurred very regularly in material from Kansas, in some instances as many as a dozen of these large beetles being present in a single stomach. *Copris*, *Onthophagus*, and *Phanæus carnifex* also were found.

Carabidæ.—Ground beetles formed 3.90 per cent of the food of nestlings compared with 5.54 per cent for the adults during approximately the same period. Of the caterpillar hunters, *Calosoma calidum* was most often fed to the young, 46 of the 778 nestlings having eaten one or more individuals. *Calosoma externum*, a still larger form, was found in numerous stomachs from Kansas, while the brightly colored and malodorous *C. scrutator* was present in 24 stomachs. Of the large ground beetles, the broad *Pasimachus* was most commonly fed to nestlings. This is especially the case in young secured in Missouri and Kansas. A brood of four, partly feathered, taken at Onaga, Kans., had eaten 17 of these large beetles, along with 3 *Calosoma externum*, 7 *Chlænius*, 2 *Scarites*, and one other ground beetle. They were present in about two-fifths of the stomachs taken in this locality, while of the total number of 778 nestlings 139 had subsisted upon them. Various other ground beetles, *Scarites*, *Harpalus*, *Evarthrus*, *Pterostichus*, and *Amara*, were present in approximately the same proportions as in stomachs of adult crows. At times, when the young were fed on members of several genera, the total number eaten was considerable. One partly feathered young had eaten no less than 60 individuals of the genera *Chlænius*, *Anisodactylus*, *Cratacanthus*, and *Scarites*.

Rhynchophora.—Nestling crows eat very few weevils. As in the case of the adults (see p. 18) the clover-leaf weevil (*Hypera punctata*) and the imbricated snout-beetle (*Epicærus imbricatus*) are the only ones worthy of note. The former was present in 32 of the 778 stomachs. One collected in Maryland contained 18 of these weevils along with 8 *Epicærus;* and another, secured in New York, had made away with 11. Imbricated snout-beetles were present in 126 stomachs, in two instances as many as 32 individuals being recorded. One of the latter two was collected in Maryland and the other was of a hatch of five secured in the District of Columbia, each

one of which had fed on these insects, a total of 62 weevils having been eaten by the brood.

Other beetles.—Other beetles fed to nestling crows belong mainly to the necrophagous and coprophagous families Silphidæ, Staphylinidæ, and Histeridæ. The proportion of these insects eaten is essentially the same as in the food of adults. No instance of extremely large numbers eaten was recorded. Click beetles (Elateridæ) and their larvæ, wireworms, form only a small portion of the nestling's food, about a third of 1 per cent, and in no stomach were remarkable numbers noted, an odd circumstance in view of the favorable reports made by competent field observers regarding the crow's effectiveness as an enemy of these pests.

Orthoptera.

In the destruction of grasshoppers, nestling crows render man a most important service. Although the birds are reared prior to the season when these insects are most abundant a vast number of the nymphal forms fall as their prey. More than 14.5 per cent of the food of those examined consisted of orthopterous remains—a remarkable proportion when it is considered that adult crows at the height of the grasshopper season in August and September take only a little over 19 per cent, and during the nestling period (May) only 4.29 per cent. It is highly probable, though, that this percentage for nestling crows is somewhat exaggerated because of the large numbers collected in Kansas and Missouri. On the other hand, no nestling material is available from the extreme Northwest, an area in which adult crows feed extensively upon these insects. Nestling crows in that region no doubt are fed largely upon Orthoptera.

By far the largest portion of orthopterous food of young crows consists of short-horned grasshoppers (Acrididæ). These were present in 528 of the 778 stomachs examined, and in many exceedingly large numbers were recorded. When it is considered, however, that the number of grasshoppers eaten is determined by counting the jaws present, and that these undigested parts are in many cases accumulated from past meals, the large numbers recorded are partially explained.

The most noteworthy work of grasshopper destruction revealed in the examination of stomachs of nestling crows was that of a brood of four secured at Onaga, Kans. These had eaten 133, 106, 105, and 74, respectively, a total of 418, which constituted three-fourths of the food. Another brood of seven had consumed a still greater number, 585, but they averaged only about 83½ for each bird and formed a little less than 70 per cent of the stomach contents. One of these nestlings had eaten 143, the highest number recorded for a single

crow, young or old. Four partly feathered young, also from Kansas, had devoured 259 grasshoppers; another brood of four made away with 222; and a series of nine, made up of probably two broods, averaged 50 apiece. Seven other individual nestlings had eaten 50 or more; 31 had taken from 25 to 49; and 44, 10 to 24 apiece. Frequently grasshoppers were associated with locustid or cricket remains, the combined bulk often forming the major portion of the food. In one stomach orthopterous insects formed the entire contents, in 35 they constituted from 75 to 99 per cent, and in 49 others they composed from 50 to 74 per cent.

Two series of young crows from Onaga, Kans., one of 157 taken in 1913 and another of 164 secured in 1914, revealed interesting data regarding the relation of these birds to grasshoppers in years when the insects are abundant. In working up this material, it was noticed that in the former year grasshoppers were by far the most important item of the diet, forming 42 per cent of the food and occurring in 151 of the 157 stomachs. In 1914 these insects constituted less than 12 per cent of the food and were present in 123 of the 164 stomachs, in many of which merely a "trace" was recorded. It was in the material taken in 1913 also that all the phenomenal records mentioned above were noted. In 1914, only 7 of the entire lot of young crows examined subsisted on grasshoppers to the extent of more than half their diet. Facts which can be correlated with this wide difference in the food of crows in the same locality in two successive years have been obtained from W. R. Walton, of the Bureau of Entomology, who has stated that, although 1913 was not a year of extraordinary abundance of grasshoppers in Kansas, 1914 was a season of uncommon scarcity, especially in spring and early summer. Exceedingly heavy rainfall is the reason assigned for lack of normal numbers. The importance of young crows as a factor in grasshopper control during an outbreak of the insects is a matter of interesting conjecture.

Lepidoptera.

Caterpillars occurred in more than a third of the stomachs of nestling crows and formed 5.34 per cent of their food. These soft, easily digested larvæ are among the first items fed to newly hatched young, but as the birds grow older other insect forms soon displace them in the diet. Birds which had been fed most extensively on them were, as a rule, less than 4 days old. A brood of four, 1 to 2 days old, collected at Onaga, Kans., had eaten over 300. Two of another brood, 3 days old, taken at the same place, had devoured 115 and 109, respectively. One partly feathered nestling had been fed over 100, and another 92. Large numbers also were found in each of

four stomachs of another brood 2 days old, but owing to the advanced stage of digestion, their number could be estimated in only one. This stomach contained 60. In comparatively few cases, though, did caterpillars constitute a large portion of the bulk of the food. One newly hatched nestling had eaten 20, which completely filled its stomach. Another, nearly ready to leave the nest, had its stomach 97 per cent full of the skins and finely-chewed vegetable food of two large caterpillars. A brood of three had subsisted on caterpillars to the extent of 87, 60, and 47 per cent, respectively, of their diet. In six other instances these insects made up over 60 per cent of the food. As in the case of the adult crows, cutworms (Noctuidæ) were found most frequently. The silken cocoons and pupæ of some of the larger moths are not uncommon ingredients of the food. In the stomach of one nestling 110 lepidopterous eggs were found.

Hemiptera.

Bugs of various kinds constituted 2.61 per cent of the food of these young birds, approximately three times the quantity taken by the parents. Of the true bugs (Heteroptera) the nestlings' share is essentially the same as that of the adults. In choice of forms eaten their taste is quite similar (see p. 23). Stinkbugs (Pentatomidæ) are the ones most often found, but in no case were they taken in large numbers. Among the Homoptera, one species, the periodical cicada, or seventeen-year locust (*Tibicen septendecim*), stands out prominently. The series of 157 nestlings secured at Onaga, Kans., in 1913, were collected just prior to the emergence of a brood of these odd insects. This brood, designated as Number IV,[1] was common in the area in which this material was secured, its range covering eastern Kansas and western Iowa and Missouri. Sixty-eight of the 157 young crows secured at this place in 1913 had fed on cicadas, nearly all of which were probably the periodical form, though accurate identification was impossible in many cases, as the insect was eaten in the pupal stage, and digestion soon obliterated important characters. A brood of 7 partly feathered crows had been fed on no less than 168 of these pupæ, one individual taking as many as 49. One from another brood had eaten 41. A series of 9, probably 2 broods, made away with 200. Eight other nestlings had devoured over 10 apiece. That these insects at times comprise a substantial part of the volume of food eaten is shown by 20 young (4 broods), which had subsisted on them to the extent of 31.3 per cent of their food. Each one had fed on cicadas and in one case they comprised 60 per cent of the stomach contents.

[1] Marlatt, C. L., The Periodical Cicada: Bull. 71, Bur. Ent., U. S. Dept. Agr., p. 43, 1907.

Other insects.

Other orders of insects are poorly represented in the food of nestling crows. As in the case of the food of adults, craneflies (Tipulidæ) are the most important of the Diptera. Of bees, ants, and wasps (Hymenoptera), young crows take only a small quantity, 0.73 per cent, but include many of the species listed under the food of adults (see p. 24). Other insect forms occurred in only negligible quantities.

SPIDERS.

Spiders constitute one of the most important food items of the young crow during the early days of its existence. In fact for the whole period of its nestling life these creatures form nearly a tenth (9.68 per cent) of its diet. They were present in 471 of the 778 stomachs, in many of these high percentages being recorded. One newly hatched bird had subsisted on spiders alone; in 7 stomachs they comprised over 90 per cent of the food; while in 32 additional stomachs they formed over half of the contents. No instances of very large numbers occurring in single stomachs were noted, 3 or 4 of the large wolf spiders so frequently eaten usually being sufficient to satisfy all needs. In only 4 cases were more than 10 spiders eaten; the highest record—15—was that of a callow young bird. The avidity with which very young crows eat these arachnids is well shown by the following summary: One hundred and twenty-six nestlings, ranging in age from 1 to 4 days, and picked indiscriminately from the material at hand, had been fed on spiders to the extent of a little less than a fourth of the food (24.5 per cent); in 80 others, 5 to 9 nine days old, spiders formed 11.6 per cent; and in 125, 10 or more days old, only 4.8 per cent of such food was recorded. In the first of these three groups only 8 of the 126 failed to have at least a trace of a spider in their stomachs; in the second series 12 out of 80 did not feed on them; while in the third lot, including many birds that were fully fledged, only about half (59 of 125) had taken them. In feeding on the different families of spiders, young crows followed closely the preferences exhibited in the food of their parents (see p. 25).

CRUSTACEANS.

The greater part of the crustaceans eaten by the young crows examined consisted of crawfish, which were taken in approximately the same quantity (1.78 per cent) as recorded for the parent birds during the same period. One nestling secured in Illinois had its stomach practically filled (98 per cent) with this food, and in 27 others these crustaceans made up more than one-fifth of the stomach

contents. A few other crusteceans similar to those found in the stomachs of adults also were eaten by the young (see p. 26).

MOLLUSKS AND FISHES.

Mollusks and fishes constitute an unimportant portion of the food of nestling crows, being negligible both in quantity (0.68 per cent) and in economic significance. Mollusks, most of which were land snails, were found only occasionally. Fish remains occurred more frequently, but it is evident that the consumption of such food is controlled largely by local conditions. Young secured in Dallas County, Mo., had eaten more than any others. Each individual of two broods of five and three, respectively, collected there, had fed on fish, which constituted about 17 per cent of the diet. This is the most extensive work of the kind noted among nestlings.

REPTILES AND AMPHIBIANS.

Reptiles and amphibians, in about equal portions, comprised 7.04 per cent of the food of nestlings. Reptiles occurred in 231 of the 778 stomachs, and, as in the case of the adults (see p. 28), snakes made up the bulk. These were found in 140 of the 231 stomachs in which reptiles occurred. A fully fledged young crow secured in Wisconsin had its stomach filled with the vertebræ and other bones of a small snake, and in nine other cases such food formed over three-fourths of the contents. Ofttimes it was apparent that parts of a large snake or turtle had been passed to several members of a brood; in fact this procedure appeared to be the rule rather than the exception, and a few cases were noted where every member of a family, old and young, apparently had shared with the others some particularly highly prized morsel. The eastern ring-necked snake (*Diadophis punctatus*) and a blue racer (*Zamenis constrictor*) were the only reptiles specifically identified in these stomachs.

Toads, frogs, and salamanders were present in 208 of the 778 stomachs, a much higher proportion than in stomachs of adults, where only 153 of 1,340 contained such food. In over half of these (110) the remains of frogs (Ranidæ) were identified, in 13 there were toads (Bufonidæ), and in 53, salamanders. Doubtless additional members of one or another of these groups were among the material which was too far advanced in digestion to be identified other than merely as amphibian. In most instances the feeding was confined to an individual toad or frog, and often parts of the same animal would be passed to one or more of a brood. In fact, this was so frequently the case among nestlings that while amphibians were present in 208 stomachs, the actual number of individuals taken was somewhat less.

A brood of four secured in Michigan illustrates this point. Notwithstanding the fact that frog remains occurred in the stomach of each and averaged over 50 per cent of the food there was no evidence that more than two individuals had been eaten. Each of another brood of five collected in Vermont also had frog remains in its stomach and, as the average portion for the lot was only 18 per cent of the stomach contents, one frog may well have furnished the food for all. Two half-grown young, also from Vermont, had eaten a toad, frog, and salamander between them, which constituted 51 per cent of their diet. Another week-old hatch of three from the same place also had the remains of probably one frog shared among them. Five young secured in Dallas County, Mo., had all fed on frogs and toads, probably three or four individuals being eaten. Each of five others from the same place had fed on amphibians, a salamander and more than one frog being identified. In one instance, where even the skin of a freshly eaten specimen was still present in the stomach, the frog remains formed as much as 83 per cent of the food.

WILD BIRDS AND THEIR EGGS.

The remains of wild birds and their eggs formed 1.57 per cent of the food of nestling crows. Birds were found in 53 of the 778 stomachs, but in four cases the material could not be distinguished from the remains of poultry. Eggs of wild birds were present in 20 stomachs. In two instances the remains of both a wild bird and eggs were found in the same stomach, so the total record of such carnivorous habits on the part of nestling crows amounts to 71 out of 778 stomachs, an average of about 1 in 11. This ratio, when compared with 1 in 28½ for the adult, probably closely represents the relative activity of old and young in the destruction of bird life.

As in the consumption of other vertebrate remains, crows frequently feed parts of the same individual to more than one nestling, which results in duplication when a count is made of the number of stomachs in which certain items are found. A brood of 4 or 5 may each have fed on the body of a nestling robin, yet only one act of vandalism on the part of the parent supplied the food. Although 71 young crows had partaken of wild birds or their eggs, only 44 broods were involved. While in a few instances more than one bird or clutch of eggs may have been present in the stomachs of one brood, the habit of passing around parts of the same individual seemed to be common. It is apparent, then, that the ratio of 71 to 778 is an ample one and that it may be reduced even more than has been indicated when it is considered that in several cases the parents of the broods also had shared with their young parts of the same food.

Each one of a brood of four collected in Kansas had been fed on what appeared to be a song sparrow, and two of the four stomachs

contained fragments of a small eggshell. Another brood of four from the same place apparently had divided a single small passerine bird between them. In two other cases were the remains of apparently one bird eaten by all of a brood. The stomach linings of these victims are among the most indigestible parts, even persisting longer than bone fragments, and at times fragments of this sac will constitute the only evidence of the deed done. In the stomach of a half-grown crow from Kansas was found the stomach lining of a small bird, intact and filled with food in a condition satisfactory for examination.

A consideration of the economic problems involved in the eating of wild birds by the crow and the testimony presented by field observers on this point is given on pages 29–36.

POULTRY AND THEIR EGGS.

Poultry and their eggs, occurring in 70 of the 778 stomachs of nestling crows, formed 1.60 per cent of the bulk of the food. In 50 of these the remains were of poultry, and in 21, eggs, one stomach containing both. The ratio of 70 out of 778 (about 1 to 11) is greater than that for the adults (about 1 to 21), but this is to be expected in view of the fact that nestling crows are fed extensively on vertebrate food, amphibians, reptiles, and wild birds, all being found more frequently in the stomachs of young than in those of adults. Field observations also have established the fact that it is the nestling which is primarily to blame for losses to the poultry raiser, as the extermination of a single offending brood will often put a stop to depredations. The records of such depredations on the part of nestlings are somewhat reduced by the fact that while 63 young had been fed on such food only 37 broods were involved, indicating that the parent birds frequently passed the especially palatable tidbits to all the family. In one or two cases the adults themselves joined in the feast.

Each of a brood of three secured in Dallas County, Mo., had been fed on one or more hen's eggs, though in bulk the shell formed only 3 per cent of the stomach contents. Three of another brood from Maryland also had their hunger appeased with similar food. Still another lot from the same State were particularly well fed at the expense of some poultry raiser. Each bird had been fed on chicken, which constituted over 40 per cent of six well-filled stomachs. Five half-grown young from Kansas had apparently all fed on a chicken, though accurate identification of the bird remains could not be made in two of the stomachs. Three of another brood of four from the same place also had partaken of similar food, which formed 44 per cent of their diet. Apparently more than one hen's egg was eaten

by three of four nestlings from the District of Columbia, as fragments of the shell made up nearly 17 per cent of the stomach contents.

A discussion of the economic aspects of this part of the crow's food habits is presented under "Food of Adult Crows" on page 36.

SMALL MAMMALS.

The efficiency of the crow in the control of mammal pests, in which it ably supplements the work of birds of prey, is occasioned largely by the food habits of the nestlings. Over a twelfth (8.83 per cent) of the food of young crows consists of mammals, the major portion of which (6.22 per cent) was found to be injurious rodents. Remains of mammals were discovered in 378 of the 778 stomachs, and of these 145 contained the pests mentioned.

As in the case of the parent birds, cottontail rabbits are the favorite mammal food of young crows, being found in 67 stomachs. Nestlings secured in Kansas were especially well fed on cottontails. At times all or nearly all members of a brood would have their stomachs distended with such food. Five partly feathered young of the same nest secured at Onaga in early May had all fed on one or more rabbits, which formed an average of 65 per cent of their diet. Each one of another brood of five from the same place also had partaken of a cottontail, but in this case the remains formed about half the stomach contents. Two more broods of three and four each had their stomachs nearly two-thirds full of such food. In several other instances also the remains of cottontails appeared in all the stomachs of one brood, but in none did they constitute over half the food. It frequently happened that each member of a brood had to be examined before conclusive evidence as to the origin of the flesh or hair which occurred in all could be obtained. The young of these mammals are torn to pieces before being fed to nestling crows, so that the investigator is often compelled to postpone definite identification of the food of a series of stomachs until the one containing a tooth, parts of a skull, or other diagnostic bones is opened.

Meadow mice (*Microtus*) were present in 17 of the 778 stomachs. In three broods of three each these rodents were eaten by all individuals, forming 36, 14, and 12 per cent, respectively, of the broods' food. White-footed mice (*Peromyscus*) occurred in 15 stomachs. These entered into the food of all ten individuals of three broods. In the case of one of the broods of three the remains of white-footed mice formed nearly two-thirds of the stomach contents: in the brood of four they constituted 62 per cent. In the stomach of one nestling of a brood of five was found the entire body of a newly born *Peromyscus*, which doubtless had been dug from its nest. House mice (*Mus musculus*) were found in two stomachs, a jumping mouse

(*Zapus hudsonius*) in one, and a ground squirrel (*Citellus tridecimlineatus*) in another. Short-tailed shrews (*Blarina brevicauda*) (in two stomachs) and bats (in two stomachs) also were eaten by nestling crows.

A consideration of the economic aspects of the carnivorous habits of the crow in relation to mammals is presented on pages 38–40.

CARRION.

Carrion formed 3.95 per cent of the food of the nestling crows examined, as compared with 2.13 per cent for the adults during approximately the same period (see Table II). As it is frequently impossible to determine with absolute certainty the character of animal food, the proportion may be subject to revision. Remains of rabbits, chickens, and parts of larger carcasses have been included under this head.

VEGETABLE FOOD.

CORN.

Of the vegetable food of the nestling crow, which formed 16.53 per cent of the diet, corn is the most important item. Some farmers have considered that the depredations on this grain in sprouting time are due largely to the nestlings' desire for the soft, germinating kernel, but stomach analysis has disproved this. Corn was found to constitute 11.91 per cent of the young crow's food, a third of the proportion taken by the adult during approximately the same time. The frequency with which these young birds eat this grain, however, gives the impression that their capabilities in this direction are more nearly akin to those of their parents. Of the 778 nestling crows examined, 354 (45.5 per cent) had fed on corn, as compared with 824 (61.49 per cent) of the 1,340 adults.

The limited quantities of corn consumed by the nestlings can better be appreciated when it is considered only 68 of the 778 had subsisted on it to the extent of more than half their food. Almost invariably the stomachs containing large quantities were those of nearly fledged birds, the character of whose food habits was rapidly approaching that of the adults. Corn eaten by nestlings less than a week old is practically negligible in quantity.

SMALL GRAINS.

Grain other than corn forms a small portion of the food of the nestling crow, but additional material collected in the Northwest may reveal greater activities along this line. Only 7 of the 778 nestlings had fed on wheat, 11 on oats, and 4 on buckwheat.

OTHER VEGETABLE FOOD.

While vegetable matter other than corn forms 4.58 per cent of the food of nestling crows, over half of this (2.32 per cent) may properly be classed as rubbish. This material, composed of bits of rotten wood, grass fibers, and leaves inadvertently picked up by the parent birds along with food for their young, is readily swallowed by their ravenous offspring, who are not troubled by doubts as to the ability of their digestive organs to care for anything possessing the slightest semblance of food. The yearly total of material classed under the headings of grass and weed seeds, cultivated fruits, and wild fruits in no case formed as much as 1 per cent. The cultivated fruit eaten during the nestling period is largely waste from the preceding year, and while some of the wheat and oats may be from the sprouting crop, the quantity actually secured from such sources is negligible.

DISTRIBUTION OF LIVE-STOCK DISEASES.

Because of its carrion-eating habits, the crow has been accused, along with the turkey buzzard, of being a potent agency in the transmission of diseases of domestic animals. Complaints of this nature have come most frequently from the Southern and Southwestern States, and in some sections farmers have regarded the crow as a most unwelcome visitor in the vicinity of live stock. The alleged distribution of hog cholera has been the commonest criticism.

Doubtless the transmission of hog cholera by the crow is possible either through virus carried on the feet, bills, or other parts of the bird or through the deposition of infected excreta after the bird has been feeding on the body of an animal which died of the disease.

However, by the immediate burial of the dead bodies of diseased animals, and the employment of most rigid sanitary measures, the objects which usually attract these birds may be eliminated. The free use of disinfectants, covering all matter that might be of food value to the crow, together with the employment of some of the usual methods of frightening these birds, such as a network of strings over pens containing diseased animals, should prove effective means of keeping the birds from the premises and reduce the danger from this source to a minimum. It is well to remember that numerous agencies, including dogs, cats, and innumerable insects, are always at work in the spread of such diseases. Thorough methods of sanitation will tend to make these also innocuous.

DISTRIBUTION OF SEEDS.

Unlike those of our more granivorous species, as sparrows and gallinaceous birds, the stomachs of crows are not capable of grinding and assimilating hard seeds. Consequently, the food value of many

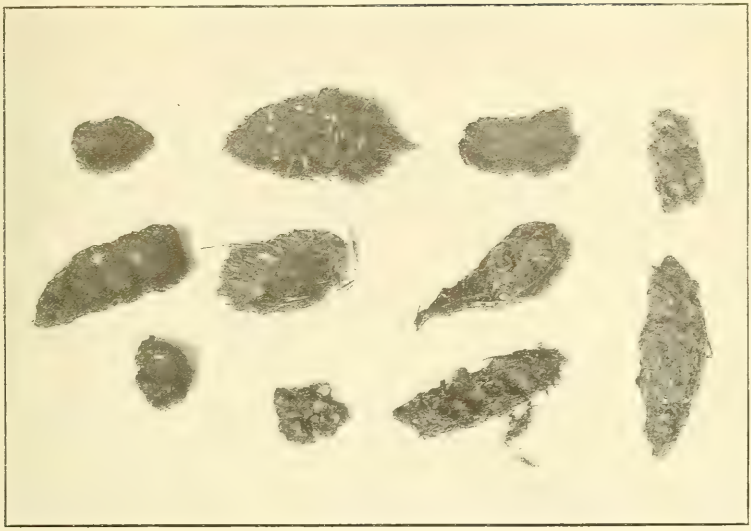

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FIG. 1.—CROW PELLETS

These consist of masses of undigested food and are disgorged in great numbers at winter roosts.

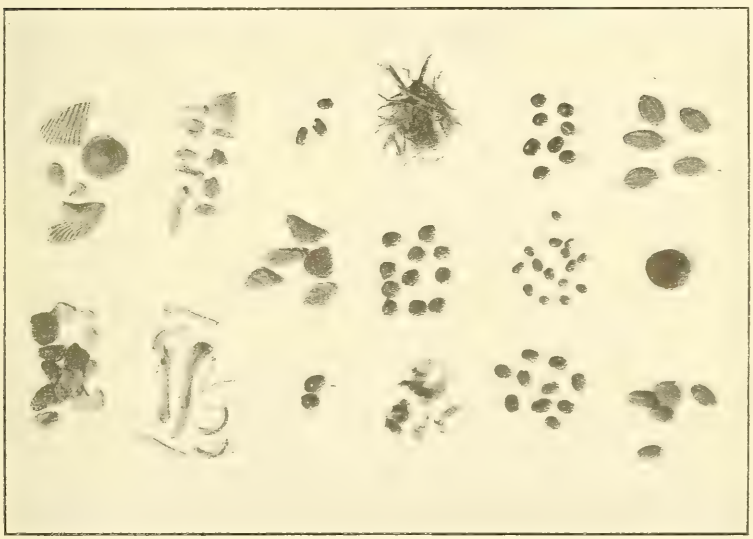

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FIG. 2.—CHARACTERISTIC INGREDIENTS OF CROW PELLETS.

Collected at the Woodridge, D. C., roost in February, 1912. Included are the wing covers of clover-leaf weevils, fragments of crawfish, land and marine mollusks, bones of a small rodent, fragments of larger bones (carrion), hulls of corn and wheat, seeds of greenbrier, sour gum, flowering dogwood, poisonous and nonpoisonous sumac, wild grape, knotweed, an acorn, and gravel.

wild fruits, as sumac, poison ivy, poison oak, bayberry, dogwood, sour gum, cherry, and juniper, ceases when the soft outer portion has been utilized. To aid even in this process of digestion crows swallow large quantities of sand, gravel, shell fragments, or anything else that will serve as a grinding medium. After a large number of such seeds have been eaten and the digestible portions assimilated, the remains are regurgitated. The fact that embryos of these seeds are seldom affected by this process, and that a large part of those disgorged are capable of germination, brings up the important problem of seed distribution.

The material so disgorged usually assumes an ellipsoid or spherical form, but is quite variable in size (Pl. II, fig. 1). These masses, commonly called pellets, as in the case of similar ejecta of birds of prey, are found in great abundance at crow roosts, and wherever a place has been occupied by these birds for several successive winters a substantial growth of their common food plants usually springs up.

An idea of the number of seeds deposited at one of these roosts may be gained from the following description given by Prof. Barrows:[1]

The following facts serve to show how extensive is this seed planting by crows in the vicinity of the winter roosts: On February 8, 1889, I visited the well-known—almost historical—crow roost located on the Virginia side of the Potomac River just opposite Washington, D. C. The exact location of this roost varies from time to time, but at the date mentioned it was entirely within the grounds of the National Cemetery at Arlington, and covered an area of 12 or 15 acres of second-growth deciduous trees. The ground beneath these trees was pretty evenly covered with the ejecta of the crows, forming a deposit which in places was an inch or more thick, though the average deposit was probably rather less than half an inch. A representative spot free from underbrush was selected, and all the material above the leaves from an area 2 feet square was carefully collected, dried, and examined. The weight of this material when dry was almost exactly 1 pound, and it contained (aside from gravel, bits of bone, shell, corn hulls, and some excrement) the following seeds:

Poison ivy (*Rhus toxicodendron*)	1,041
Poison sumac (*Rhus venenata*)	341
Other sumacs (*Rhus*)	3,271
Juniper or red cedar (*Juniperus virginiana*)	95
Flowering dogwood (*Cornus florida*)	10
Sour gum (*Nyssa sylvatica*)	6
Total	4,764

A little calculation shows that the roost of 15 acres must have contained upward of 778,000,000 seeds, or more than enough to plant 1,150 acres as thickly as wheat is sown.

A series of nine pellets, gathered at a former roost near St. Louis, Mo., and examined by the writer, contained an average of 36 poison-

[1] Barrows, W. B., The Common Crow of the United States: Bull. 6, Div. of Ornith. and Mamm., U. S. Dept. Agr., pp. 23–24, 1895.

ous *Rhus* seeds (poison ivy and poison sumac) for each pellet. Along with these were seeds of nonpoisonous sumac, grapes, dogwood, hackberry, wild bean (*Strophostyles*), and buckthorn (*Bumelia*). A mass of material gathered at a roost near Baltimore contained 156 seeds of poisonous *Rhus*, estimated to be 25 per cent of the bulk of the pellets. These also contained 11 seeds of nonpoisonous sumac, 6 of greenbrier, 4 of juniper, and 1 of hackberry. W. L. McAtee, of the Biological Survey, has informed the writer that at the roost formerly located at Woodridge, near Langdon, D. C., he recorded the following species of plants in such abundance as to justify the belief that they had sprouted from seeds brought there by crows: Poison ivy, poison sumac, flowering dogwood, sour gum, arrowwood, and frost grape. He also stated that in 1 square yard there were 51 plants of poison ivy.

The seeds deposited at winter roosts form only a portion of the material of this character cast up by these birds (Pl. II, fig. 2). These pellets are dropped here and there over the birds' daily feeding range, and under such circumstances probably a much greater proportion of the seeds sprout. Conditions in the average roost are not advantageous to the germination of a large part of the deposited seeds, especially in the dense pine woods so frequently chosen.

When the seeds thus distributed are of valuable trees and shrubs or even of harmless plants, the crow no doubt is performing a distinct service, but the dispersal of seeds of poison ivy and poison sumac must be considered undesirable. Examination of 1,340 stomachs of adult crows showed that seeds of these poisonous weeds constitute 1.49 per cent of the yearly food. Most of them are eaten during fall and winter, January being the month of greatest consumption (5.02 per cent). When it is remembered that practically all these seeds would develop into weeds of the most noxious character should they be deposited in a favorable environment, it is not surprising that the crow has been the subject of considerable criticism on this score.

While it must be admitted that no agency aiding in the reproduction of poisonous plants should receive encouragement, it will be well before being unduly severe on the crow to notice other factors working toward the same end. Records of birds' stomachs examined by the Biological Survey show that no less than 65 species of birds feed on the seeds of poisonous *Rhus*. Many of these birds possess the same objectionable habit of regurgitating the seeds, and in several cases the percentage of such food eaten exceeds that of the crow; but none of them leaves so large a part of the seeds of poison ivy and poison oak in places where they will never germinate as does the crow. The latter, then, is in a way conferring a benefit in feeding on these seeds, as by so doing it reduces the supply which otherwise

would be available for more potent seed distributors. Nor in extending its range is poison ivy dependent entirely upon the transportation afforded by bird life. It readily reproduces itself through its roots and ofttimes spreads over considerable areas in spite of vigorous efforts to exterminate it. It is apparent, then, that even the total extermination of the crow would have little effect upon the growth of poisonous *Rhus*, inasmuch as there are many other agencies effecting the same results. The problem is one similar to that of the dissemination of live-stock diseases, the control of which some persons maintain can be effected by the elimination of crows and turkey buzzards, overlooking the fact that there are numerous other agencies engaged in the work of dispersal, and that the removal of only one or two would result in no appreciable relief.

NATURAL ENEMIES.

Aside from man the crow appears to have few natural enemies. His unusual wariness stands him in good stead in avoiding many of those mammals and birds which prey to a considerable extent upon bird life. The great horned owl alone seems to be inclined to feed on the crow as a more or less regular item of diet. Ample opportunity is afforded this species to secure such food at crow roosts, which it appears to frequent regularly for this purpose.

In this connection, E. H. Forbush, of Massachusetts, has said:[1]

> After the first fresh snowfall, I visited an extensive roost, finding the feathers and a few other remains of a freshly killed crow. At the spot where the crow was borne to the ground were the strong imprints of the characteristic tips of the wings of the great horned owl. These owls habitually take crows from their roosts or nests at night.

The antipathy between crows and owls as a class is frequently manifested in the "mobbing" of one of the latter by a large number of crows. Recognizing the comparative helplessness of these nocturnal birds of prey when subjected to bright daylight, the black fellows appear to take great delight in molesting them when they are found abroad during these hours.

G. B. Wellman, of Malden, Mass., reports:

> The chief thing that our crows in the fells seem to busy themselves with in the winter months is harassing the owls. They have in consequence driven nearly all the barred and screech owls from the park. There has been, I am sure, an added nuisance made here by the increase of the noxious rodents since the owls left.

Occasionally the red-tailed and red-shouldered hawks will turn upon their tormentors. Examination of stomachs by Dr. Fisher revealed six records of this work on the part of the former and one by the latter bird.

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[1] Forbush, E. H., Two Years with the Birds on a Farm, p. 39, 1908.

The attacking and driving away of crows by smaller species is a matter of common knowledge. This is especially true of the kingbird, which appears to maintain a sworn vengeance against its much larger relative. Its antipathy is most marked during the nesting season, when a pair or two of kingbirds are frequently an effective means of protecting poultry and crops in the immediate vicinity of their nests. In this connection, Maj. Allan Brooks, of Okanogan Landing, B. C., remarks, in a letter to the Biological Survey, that "the crows are generally kept away from the immediate neighborhood of houses and poultry yards by the number of kingbirds (two species) present." Though other small birds vigorously attack crows when the young or eggs are in jeopardy, none appears to possess to the same marked degree the unceasing animosity of the kingbird.

Probably the most important natural agency in the reduction of the number of crows is a disease popularly referred to as "roup." Though no exhaustive study of this malady has been made, a few points regarding its nature have been established. Technically it may be termed an ulcerative keratitis, in which there also appears an inflammation of the mucous membranes, accompanied by exudations from the eyes and nostrils. In severe cases the secretion about the eyes covers the cornea and blindness follows. Experiment has proved that the disease is contagious among crows, and also that it is specifically different from the roup of poultry.[1]

Heavy inroads have at times been made by this malady on the numbers of crows at their winter roosts. Becoming partially or totally blind in the advanced stages of the disease, the disabled birds suffer from lack of food and soon succumb under the combined attacks of disease, hunger, and cold, or fall easy prey to the predatory mammals and birds which take advantage of their helplessness. In one instance the writer witnessed a barred owl, closely pursued by a large flock of frenzied crows, making away with a sick individual too weak to resist.

Prof. E. H. Eaton, describing an outbreak of this kind, states:[2]

> About the middle of December, 1901, a malady broke out among the crows (*Corvus americanus*) of Ontario County, N. Y., which, ere spring, had decimated the ranks of the local "roost." As soon as winter had fairly begun reports commenced to come in of crows which had been "blinded by freezing of their eyes," as the farmers expressed it. * * *.
>
> All the sick birds were suffering from an acute inflammation of the pharynx and the anterior portion of the head, including the nostrils and eyes. Often there was a mucous discharge from the nostrils. The eyes were usually blinded by a membrane forming over the exterior of the cornea. Sometimes only one eye was seriously affected, and this was usually the left one, as far as I noticed. If this membrane was rubbed off the eye looked quite clear again

[1] Information supplied by the Bureau of Animal Industry.

[2] The Auk, XX, pp. 57–58, 1903.

and sight was temporarily restored, but within half an hour the membrane reformed and the patient would flutter about like a bird with the cerebellum destroyed or with the eyes shot out.

That death ensued from the acute disease and not merely from starvation due to blindness was abundantly proved by caring for sick birds and forcing food down their throats, for they died in nearly every instance. While it is true that those birds which survived the disease were, in every instance, birds that had been blinded in only one eye, we believe that this merely indicates that the roup was less severe in those cases, which was the cause at the same time of the slight affection of the eyes and of the bird's recovery.

In 1901 R. J. Weith, of Elkhart, Ind., reported that he was confident that 10,000 crows died within a radius of 2 miles of that place, due, probably, to an epizootic of "roup."[1]

The late Prof. F. E. L. Beal related having seen birds at the roost near Langdon, D. C., affected by this disease in the winter of 1901. Several hundred birds, partially or totally blind, were noticed aimlessly pecking at branches and running their bills along them in a fruitless endeavor to find food. These birds were too seriously affected to accompany their companions on their daily search for food.

The writer has witnessed mild outbreaks of this disease at the Langdon (D. C.) roost during the four winters from 1911–12 to 1914–15. In each year a few score of birds were found dead. All the sick birds which were kept in captivity and forcibly fed died within three or four days. During the winter of 1913–14 the disease was prevalent among crows throughout adjacent parts of Maryland and Virginia.

In the reduction of the number of crows by natural agencies no other single factor appears to be so potent as this disease. Birds that do not succumb are often so enfeebled that their capture by predatory animals is comparatively easy.

PROTECTION OF CROPS.

The ravages of crows upon fields of grain and other crops have been matters of record almost from the beginning of agricultural activities. Before the advent of firearms and the use of poisons and deterrents of various kinds the protection of crops was intrusted entirely to "grain minders," whose constant presence in the fields during all hours of daylight was necessary. When the early colonists attempted to cultivate limited areas of corn and other grain along the Atlantic slope, they found themselves confronted with many of the same problems that had occupied their attention in Europe. The American crows became as troublesome as the rooks, hooded crows, and jackdaws had been in their former homes. Some

[1] Country Gentleman, LXVI, 2520, pp. 412–413, 1901.

of the landowners, especially those in the southern colonies, still resorted to the "grain minder"—the negro children in many cases being thus employed. At the same time various mechanical devices came to be used to do the tedious work, and experiments, which doubtless had their origin in Europe in the use of certain deterrents applied to the seed grain, also were tried, thus making the crops in question at least partially immune to the attacks of these birds. Several of these deterrents have proved effective and by their use many farmers have reduced in large measure their annual losses from crows.

FRIGHTENING DEVICES.

It is not necessary to describe in detail the many well-known devices employed as "scarecrows." These include the time-honored straw-stuffed human effigy; various unusual objects, as pieces of shining tin moving in the wind, glass bottles, windmills which operate noise-producing mechanisms, ears of corn and newspapers placed on the ground; twine stretched about and across the fields from poles placed at intervals; and bodies of dead crows hung in conspicuous places. One or another of these contrivances has brought the desired results on occasions, but all have failed at other times. None can be considered infallible.

DETERRENTS.

Much of the damage to corn and other grains is at sprouting time. The difficulty, however, has been met fairly well by the application of deterrents upon the seed. Experiments along this line have been made for many years and as early as the beginning of the nineteenth century methods had been perfected. Even at that time several different substances had been used to coat the seed. The most successful involved the use of coal tar. Since these early experiments many other methods and formulas embodying the use of tar have been devised. These, however, varied but little and aimed merely to secure an even and thorough coating of the seed, which was followed by a drying process either by spreading the grain or by the application of some drying medium, as lime, ashes, or land plaster.

A few years ago the Kansas State Agricultural College Experiment Station conducted a series of experiments to ascertain the usefulness of certain deterrents on seed grain against burrowing animals. Incidentally the effect of these various substances upon the germinating powers of the seed was investigated. In a report[1] on this work, Theo. H. Scheffer stated in part:

> Kerosene, crude petroleum, copperas, crude carbolic acid, fish oil, and spirits of camphor, when used in sufficient quantity or strength to impart an odor to the corn, seriously injure the germinating powers of the grain. To treat the

[1] Circ. 1, Kansas State Agr. Coll. Exp. Sta., p. 3, April 28, 1909.

seed with any of these substances in such small quantity or dilute form as not to injure the germ is a waste of time, for the slight taste or odor imparted is soon dissipated in contact with the soil.

Mixing pulverized gum camphor with the dry grain and storing it in a closed vessel for some days has been recommended as an efficient treatment. With us the results were entirely negative. Little or no odor was imparted to the grain. Pine tar was used in our experiments. It has a strong odor, but leaves the grain too sticky to work in a planter.

Coal tar makes an ideal coating of a rich brown color and a persistent, gassy smell. It dries nicely, is not in the least sticky, and will work well in a planter. Wet the grain with a little warm water before stirring in the tar. A teaspoonful of the latter will be sufficient for a peck of corn. The mass must be thoroughly mixed and then dried before attempting to plant.

Valuable experiments showing the effect upon seed grain of the various deterrents against crows were conducted by B. M. Dugger and M. M. McCool at the Agricultural Experiment Station of Cornell University. The following is an extract from their report:[1]

Considering the practices now more or less commonly employed, it seemed desirable to give the coal tar a careful experimental trial, and, at the same time, to employ other substances with objectionable odors or tastes. Accordingly, experiments were arranged for the treatment of seed with the following substances, namely, coal tar, pine tar, oil of turpentine, anilin oil, and pyridine. * * *

Some difficulty was anticipated in securing a more or less equal distribution of the small amount of tar upon so large a volume of seed, but it was found that this could be accomplished by repeated stirring or shoveling of the seed. Tar at the rate of one or two tablespoonfuls per 10 quarts of seed was sufficient effectively to coat almost every seed in the mass. This was true in the case of both the coal and the pine tars. It was therefore evident that any of the materials mentioned could be employed so far as convenience is concerned. In employing pyridine and anilin oil 10 per cent solutions were used, and with turpentine a 10 per cent emulsion. In these solutions the seeds were soaked for a period of two or three hours.

After treatment the seeds were sown in pots containing a sandy loam soil, this in order to determine the effect of the treatment given upon germination.

The results of this germination test showed that seed treated with pine tar, coal tar, and pyridine solution (three hours) gave the most favorable results—a germination of between 98 and 100 per cent, which was equal to that of the untreated seed used as a check. Turpentine emulsion (three hours), turpentine emulsion (four and one-half hours), and anilin oil solution (three hours) gave percentages of 38, 8, and 0, respectively. The report continues—

The results of these experiments demonstrate conclusively, it would seem, that the use of tar in no way prevents germination. It might be further stated that germination was not retarded by the use of tar in the experiments above mentioned. Again, varying quantities of the tars were also employed with similar results. In other experiments the seeds were planted in moist paper and com-

[1] Circ. 6, Cornell Univ. Agr. Exp. Sta., pp. 14–16, May, 1909.

pared with control experiments under similar conditions. In no case was any injury by the tar demonstrated. The same results were secured when the treated seeds were spread out and permitted thoroughly to dry before being planted. * * * Some surprise, however, was felt at the result of the use of turpentine, for the experiments demonstrated that a protracted treatment with this substance is extremely injurious. * * *

Corn freshly treated with either of the tar preparations could not be employed in the corn planter without experiencing great difficulty in uniformly dropping the seed. On the other hand, it is found that when properly spread on the dry floor the treated corn will completely dry out in a few days so that it may be used without difficulty in a planter. According to the experience of others a quart or two of fine land plaster or sifted ashes may be mixed with the seed immediately after the tar treatment, and the treated seed may in this way be used immediately without serious inconvenience. In this case it would perhaps be wise to use a minimum amount of tar.

Reference is then made in the report to similar and more extensive experiments conducted at the Illinois Agricultural Experiment Station,[1] which produced the same favorable results in respect to use of coal tar.

These various experiments demonstrated conclusively that the use of coal tar according to the formulas and methods stated is in no way injurious to the seed itself. Germination, however, is delayed slightly even under conditions favorable to growth, and in times of drought this delay may be two or three days.

That the process of treating the seed with tar has met with favorable results in deterring crows from the sprouting grain in this country has been demonstrated repeatedly by many practical farmers. It appears from the mass of correspondence received from those acquainted with modern farm methods and practices throughout the country that the tarring of seed grain is most extensively practiced in the North Atlantic States. Though a vastly greater amount of corn is raised in the States of the upper Mississippi Valley, seed corn is seldom tarred there. From the same reports it is learned that, when properly done, tarring has almost always proved successful and, beyond the pulling of a few spears of grain (enough to get a taste of the tar), the crows usually inflicted no further damage.

Accordingly, it may be recommended that coal tar used at the rate of about a tablespoonful to a half bushel of seed grain, which has been previously heated with warm water, and then drained, is a fairly successful crow deterrent. A continued stirring of the grain will eventually permit an even coating of tar. The seed must then be spread on a dry surface, or drying may be facilitated by the application of some absorbent medium, such as ashes, land plaster, or powdered earth. When thoroughly dried the grain may be used

[1] Forbes, S. A., Bull. 130, Ill. Agr. Exp. Sta., Dec. 1908.

in a planter. Coal tar is a cheap by-product in the manufacture of illuminating gas and may be procured at gas works or paint shops.

The manufacture of deterrents for use on seed grain has been undertaken on a moderate scale in this country, and a few articles of this nature also have been imported. Most of these appear to contain coal tar or closely related products as a base, while at least one of the imported deterrents is a dye. There is no evidence that any of these manufactured substances is superior to coal tar when the latter is properly applied.

Some success has been attained with red lead for the same purpose. This deterrent has been used in Europe for some time, but in this country its use has been confined to recent years. A method of applying the red lead with the aid of a glue size has been suggested by a Pennsylvania farmer:[1]

> One-half pound of glue was dissolved in 1 quart of warm water and when dissolved 5 or 6 quarts of warm water was added. Into this, corn, enough to be covered by the liquid, was added. The excess of liquid was then drained and red lead was added until well colored.

Though this process has been little used in this country, its success in deterring birds in Europe warrants further trial.

SCATTERING OF GRAIN.

Many farmers have had considerable success in protecting their sprouting crop by spreading broadcast over fields a quantity of grain previously softened with water. This the birds take and leave untouched that which has been planted. It has been found that a comparatively small amount sacrificed in this way has often prevented loss to the growing crop.

POISONING.

Though it would be most difficult to eradicate the crow over any considerable area by a campaign of poisoning, due largely to the bird's wariness, this method has been found effective in protecting crops. When once a flock of these birds have learned, through the loss of one or more of their number, that a certain area has been well baited with poisoned food, they are inclined to avoid it for some time at least. But as there is always an element of danger connected with the distribution of poison in thickly settled regions, its use should be limited and judicious.

Corn is generally employed as a bait in poisoning and it is usually prepared by simply steeping in a strong strychnin solution. If the poison is made, however, according to the following recipe it will kill

[1] Rural New Yorker, LXI, 2727, p. 345, 1902.

more quickly and its effectiveness will last for a considerable time even when exposed to weather:

Corn	20 quarts.
Strychnin (powdered)	1 ounce.
Starch	2 tablespoonfuls.
Water	1½ pints.

Mix the starch and strychnin in the water and heat to boiling, stirring thoroughly after the starch begins to thicken. Pour this mixture over the corn and stir till every kernel is coated. The corn may then be spread out and dried.

Successful results also have been obtained by the use of partially blown hens' eggs into which a small quantity of strychnin has been injected. These should be placed on the tops of stacks or in inclosures from which poultry and all farm animals are barred. Carrion or meat of any kind is another convenient and efficient medium for the poison. Such bait works best in winter when the birds are hard pressed for food.

TRAPPING.

Trapping has brought relief at times when other methods have failed. No wholesale reduction in the number of crows has ever been accomplished by this method, but when once a few of these birds are trapped and their dead bodies hung up about the fields their relatives are inclined to shun the immediate vicinity. These birds have been secured mainly in steel traps carefully concealed and baited with hens' eggs.

SHOOTING.

Continued persecution of crows with firearms has at times brought relief from their depredations, but the unusual wariness of these birds has made this method of killing them difficult. The use of crow decoys and crow "calls" to attract them within gunshot has been resorted to with more or less success. Placing a stuffed owl in a conspicuous place and within easy gunshot has been successful in luring number of crows to a point where they can be shot.

Writing of the fish crow in this connection, Louis A. Zerega states:[1]

Mr. Keller shot most of the specimens that were killed by him from the cover of a "blind" over "decoys" (which are simply pieces of blackened pasteboard of bird shape, set up at different angles so as to present a side toward each direction). As the crows fly over they see the "decoys" and, supposing the place to be a good feeding ground, fly toward it; I have even seen common crows alight before discovering their mistake.

Frank M. Chapman gives an interesting account[2] of an attack made by crows upon a mounted barred owl. After placing the

[1] Bull. Nuttall Orn. Club, V, No. 4, p. 206, October, 1880

[2] Bird Lore, XI, No. 1, p. 4, January-February, 1909.

mounted bird in a favorable place and carefully concealing himself he gave the call of the barred owl and—

> in a moment or two the expected response came from a neighboring wood, and very shortly the usual throng of crows had gathered at the part of the woods nearest to the tree in which I was concealed * * *. For some time * * * they circled overhead in winged reconnaissance until one of the birds actually saw the mounted owl in the tree below. Caution was at once abandoned, and, uttering the battle cry of his kind, he, with his fellows, advanced to the attack. A dozen or more of the birds took up positions in or near the tree in which the owl sat so calmly * * *.

Justus von Lengerke, writing to the Biological Survey, says that hundreds of crows are killed in spring and fall by using great horned owls to decoy them to the gun, thus giving the farmers within a radius of several miles much relief from the crow nuisance.

Regarding the use of crows in place of other live birds or "clay pigeons" in trap shooting, Henry W. Foster, of the Philadelphia Academy of Natural Sciences, stated in a recent communication:

> Many crows have been trapped and used for shooting, including both species, but, so far as my meager observations go, the practice does not seem to have diminished their number.

In the same connection, Mrs. George S. Morris, of Olney, Philadelphia, Pa., has written that about 15 years ago great numbers of crows were caught and used in place of pigeons for trap shooting. This was kept up for several years and had a distinct effect on their numbers. To capture crows for use in this way a dead horse or cow was placed in a field as a bait. When the crows had assembled on the carcass in great numbers a net, operated from a distance by a cord, was sprung over them.

The possibilities of crow shooting as a means of sport have appeared so favorable, as well as so fitting a way to reduce the number of these birds in restricted areas, that crow decoys and "calls" have been manufactured and placed on the market.

The systematic destruction of crows' nests has frequently brought about desirable results in farming communities where woodlands border the fields in which tempting crops are raised. This procedure also has been adopted successfully in cases where the parent birds habitually visit some particular poultry yard in search of eggs or young chicks. In winter, when these birds gather in large numbers at their roosts, raids by gunners for several successive nights usually cause them to move on. In thickly settled areas where the discharge of firearms would be inadvisable Roman candles shot among the roosting birds should bring about the same result.

In summing up it must be said that, with the possible exception of the protection of sprouting grain by means of deterrents, no single method for the protection of crops against crows can be considered

infallible. Such local conditions as the proximity of their nests or roosts, abundance of natural food supply, availability of cultivated crops, and the varying boldness of these birds in different localities are factors requiring varying methods of control. A sure preventive of losses from crows in one locality often utterly fails in another, and likewise a method of protection may work admirably for a time only to fail completely when once the birds become acquainted with it or learn to avoid its consequences.

LEGISLATION.

In the game laws of most of the Western States, where the crow is too scarce to be of great economic importance, its name does not appear among the exceptions to protection, where in other parts of the country it is usually listed. The crow is thus protected in Arizona, California, Colorado, Idaho, Nebraska, Nevada, New Mexico, Utah, Washington, and Wyoming. In some of these States, however, provision is made whereby the owner of crops subject to injury by crows may kill these birds when they are doing damage. Of the Eastern States, Delaware is the only one in which absolute protection is afforded, no provision being made for the destruction of crows under any circumstance; while in the remaining States the crow is either specifically exempted from protection or is allowed to be shot by the owner or lessee of property on which it is doing injury.

Wherever crows have been troublesome the enactment of bounty laws for their control has been common. Rewards for the destruction of the birds have been offered by States, counties, townships, and in some instances by communities of farmers or by sportsmen's associations. Among the earliest laws enacted by the colonial governments were those dealing with the reduction of crows by bounties, and a perusal of recent statutes will show that this method is still popular.

In 1904, Rhode Island passed a bounty law which provided for the payment of 25 cents apiece for crows and certain birds of prey. Indiana authorized, in 1911, a bounty of 10 cents a head for the birds and 5 cents an egg in lots of not less than 10. All counties in Kansas pay 5 cents for the birds and 1 cent apiece for the eggs. West Virginia allows 10 cents apiece for the birds. Illinois, Maryland, Minnesota, North Carolina (one county), and Wisconsin also have had bounty laws in effect within the last nine years. Most frequently payments are optional with the counties, although in some cases, as in Kansas, it is mandatory.

At times the management of game preserves or farms offers rewards for the destruction of these birds in the immediate vicinity of reservations. In this connection Jonathan B. Gadsden, manager of

the Oakland Club, in South Carolina, has written: "I pay 10 cents for the bill of every crow, but can honestly say I see no great benefit nor any decrease in numbers." (1912.)

A. W. Perrior, of Syracuse, N. Y., states that "the Anglers' Association of Onondaga County offered a bounty of 5 cents a head three years ago but there were very few heads brought in, due to the fact that the price offered was too small." (1912.)

Notwithstanding the popularity of the bounty system, it has several objectionable features which make it not only unsatisfactory, but also dangerous. Its efficiency in reducing the number of crows over large areas is to be seriously questioned, inasmuch as the comparatively small sum which can be offered does not often furnish a sufficient incentive for a persistent warfare of extermination. At the same time the opportunities and incentives for fraudulent practices are numerous.

In many localities in which bounties have been paid more or less continuously for many years, crows are still found in considerable numbers, and, judging from the amounts being paid from year to year for bounties, the birds do not appear to be in immediate danger of extermination. The numbers of crows have been reduced to some extent in comparatively restricted areas when bounties were reasonably attractive. On the other hand, cases have come to attention where the numbers have actually increased in areas where bounty laws were in force.

To enter into a discussion of the various ways in which bounty laws have led to fraudulent practices would extend this bulletin beyond its legitimate scope. It will suffice to say that bounty systems against crows will continue to result in meager returns for the money invested as in the past, and at the same time will be liable to produce conditions savoring of the iniquity with which so many of these systems have been associated.

SUMMARY.

A brief summary of decisions reached respecting each of the more important economic problems that have arisen in this investigation will make it possible to review with some degree of thoroughness the many-sided question of the value of the crow.

FOOD HABITS.

Insects.

The crow's destruction of insects presents the strongest argument in the bird's favor. Nearly a fifth of the adult crow's yearly sustenance comes from such sources, and a great part of the insect material is eaten early in spring, a time when the life cycles of many of

the most destructive pests are at their lowest ebb. A little later, nestling crows appear on the scene, outnumbering their parents two to one, and assist in the work of destruction. Not only do the young birds eat a much larger proportion of insect food than do their parents at the same time of year, but the quantity of food required to develop their rapidly growing bodies is considerably greater. That injurious insects greatly outnumber beneficial insects in the diet of the crow will be seen from the following review of the four most important orders:

Beetles.—The crow's relation to beetles is all that the frugal agriculturist could desire. Foremost among these insects in its food are May beetles and their destructive larvæ, white grubs. These, with a few other phytophagous scarabæids and scavengers of the same family, as disclosed by stomach examination, totaled over half the beetles eaten. The destruction of a few click beetles, weevils, and wood-boring beetles also must be considered in the bird's favor. Ground beetles, most of which are beneficial, made up about a fifth of the beetle food and must be charged against the crow. Coprophagous and necrophagous forms eaten, as Silphidæ and Staphylinidæ, are slightly beneficial.

Grasshoppers.—In its consumption of grasshoppers the crow renders man its most important service. In regions where these decidedly injurious insects are abundant their nymphs form the principal insect-food of nestlings. Not only do the food habits of these young birds exert a strong control on the increase of grasshoppers, but the destruction of these insects is accomplished so early in the season that it has the added effect of preventing much of the damage which would be inflicted if the work were delayed till later in the year.

Caterpillars.—In its consumption of caterpillars the nestling crow exceeds its parent in effectiveness in the ratio of about 4 to 1. This food, found in over a third of the stomachs of young crows, is all in the bird's favor, especially since cutworms constitute the major portion.

True bugs.—Among the true bugs, only soldier bugs (Pentatomidæ) and the periodical cicada are worthy of mention in this summary. The former, taken in small quantities on numerous occasions, embrace both predacious and herbivorous species, an indiscriminate destruction of which must be largely neutral in effect. The destruction of the periodical cicada must also be considered of minor economic importance.

Spiders.

The exact economic status of the large wolf spiders (Lycosidæ), which comprise the major part of the arachnid food of young crows,

is not satisfactorily known. The fact that they are terrestrial in their feeding eliminates from their diet many of the injurious plant-feeding and flying-insect pests, while most of the beneficial, predacious forms are subject to their attack. Thus their destruction by the crow can be considered only partially prejudicial to the interests of man.

Crustaceans

The consumption of crustaceans must be classed among the minor benefits conferred by the crow. While much of this food is picked up as carrion along beaches or river banks, a considerable number of crawfish fall as the crow's prey in portions of the South where these creatures are abundant and destructive.

Reptiles and Amphibians.

Feeding on the smaller snakes and lizards must be charged against the crow, but by the destruction of a few larger, more or less arboreal serpents the bird compensates for some of its own misdemeanors against nesting birds. While it is impossible to determine the exact extent of the crow's predacious activities against the larger snakes, it follows that in the consumption of any such material the bird confers a benefit either as a carnivore or scavenger. Most of the large turtles eaten probably are carrion, while the smaller ones are frequently captured alive.

The crow's destruction of the highly insectivorous amphibians, especially toads and frogs, is to be deplored. Such work is opposed to the best interests of man, but, fortunately, toads, which come most intimately in contact with insect pests of garden and field, are less frequently eaten than frogs.

Wild Birds and Their Eggs.

The crow's destruction of wild birds and their eggs is a noxious trait of no small importance. It is somewhat mitigated, however, by the fact that most of the depredations on eggs occur early enough in the season to permit the raising of a second brood at a time when there is little or no danger from crows. To this fact alone can be attributed the ability of some waterfowl to maintain their numbers in regions where they are regularly subject to attack. The destruction of nestling birds of highly beneficial species is not to be condoned and constitutes one of the strongest arguments against the crow. On game farms, preserves, and in suburban districts where it is the desire to foster small birds, the crow population must be kept within limited numbers. Sufficient cover also must be left for woodland game birds.

Poultry and Their Eggs.

The molesting of poultry by the crow is an injurious habit against which protective measures are effective under any but the shift-by-itself method of caring for fowls. A little attention to the screening of young chicks and the suitable housing of nesting fowls will obviate most losses of this kind. The trait appears to be one of the individual crow working under favorable conditions. In breeding time, when most losses of this kind are suffered, the destruction of a single near-by nest of young crows will often put a stop to the nuisance.

Small Mammals.

Inasmuch as most of the small mammals destroyed by the crow are rodents, the bird's activities in this direction are mainly beneficial.

Annoyance of Live Stock.

The molesting of such live stock as young lambs and swine, an occasional habit of the crow when hard pressed for food, is to be condemned. Fortunately such work is not common, and the aggregate loss of this kind is negligible.

Carrion.

In the Southern States the crow ably supplements the work of the turkey buzzard as a carrion feeder, while in the interior portions of the North he is the principal scavenger among the land birds.

Corn.

Corn is the principal food of the adult crow. It is eaten in every month of the year, and from October to January forms over half the bird's diet. Much is waste grain, but in sprouting time and when corn is "in the roasting ear," and even when it is ripe and standing in the shocks the crow inflicts damage. Deterrents, as coal tar, on the seed have greatly lessened losses of newly sown grain, though the crow still reaps considerable toll. When "in the roasting ear" the corn crop is especially subject to most annoying attacks, and for this there is no effective remedy. The ripened grain seems less palatable, and, while a large quantity is eaten, it is apparently taken more from necessity than choice. Prompt harvesting of the crop will greatly reduce such losses.

Other Grain.

Damage to wheat and oats is confined mainly to sowing and sprouting time, and is by no means so universal or serious as the pilfering of sprouting corn.

Miscellaneous Crops.

Melons, especially watermelons, are at times considerably damaged by the crow in southern States; small fruits occasionally are attacked; and still more rarely crops of cultivated nuts and garden truck are levied upon.

DISTRIBUTION OF LIVE-STOCK DISEASES.

As a distributor of disease the crow, along with the turkey buzzard, has been a target for much unjust criticism. While the crow may be an agent in the transmission of live-stock diseases, it does not follow that even the extermination of this species would materially lessen the danger of infection. As the agencies at work in the transmission of virus are many and difficult of control, the elimination of but one would aid little. Inoculation and the strictest sanitation and quarantine are the farmer's strongest weapons in the fight against such epizootics.

DISTRIBUTION OF SEEDS.

The crow's consumption of wild fruit in itself involves nothing of economic interest, as the embryos of the seeds eaten are seldom destroyed, but as this material is regurgitated after the digestible portion has been assimilated it is apparent that the crow thereby becomes an agent in the dispersal of seeds. When engaged in the distribution of seeds of valuable or even harmless trees and shrubs, the crow is conferring a benefit; but when it assists in the spread of such noxious plants as poison ivy and poison oak, the opposite interpretation must be given. Since, however, numerous other birds have the same objectionable habit, the crow's consumption of such seeds has a limited influence for good; the large quantity it devours doubtless reduces the supply available for other species which do not deposit so large a percentage of the seeds in places where they will never sprout as does the crow.

CONCLUSION.

When feeding on injurious insects, crustaceans, rodents, and carrion, and when dispersing seeds of beneficial plants, the crow is working largely for the best interests of man; when destroying small reptiles, amphibians, wild birds, poultry, corn, and some other crops, when molesting live stock and distributing their diseases, and when spreading seeds of noxious plants, the bird is one of the farmer's enemies; when destroying spiders and mollusks, however, its work appears in the main to have a neutral effect. The misdeeds of which the crow has been convicted greatly outnumber its virtues, but these

are not necessarily equal in importance. Much of its damage to crops and poultry can be prevented, while the bird's services in the control of insect pests can ill be spared. At the same time no policy can be recommended which would allow the crow to become so numerous that its shortcomings would be greatly accentuated. As the capabilities of the crow for both good and harm are great, it is believed that an extermination of the species would have ultimate consequences no less serious than an overabundance.

Inasmuch as this investigation aimed at reaching general conclusions respecting the status of the crow, in order that our attitude toward the bird might be based on sound economic principles, it may be said that the laws relating to it, at present in force in most States, are altogether satisfactory. It is well that no protection be afforded the bird and that permission be granted for shooting it when it is actually found doing damage. Bounties can not be recommended, neither can a campaign of wholesale destruction where complete extermination is the object sought. However, a reasonable reduction of numbers is justifiable in areas where there is an overabundance of the birds. The attitude of the individual farmer toward the crow should be one of toleration when no serious losses are suffered, rather than one of uncompromising antagonism resulting in the unwarranted destruction of these birds which at times are most valuable aids to man.

LIST OF ITEMS SPECIFICALLY OR GENERICALLY IDENTIFIED IN THE 2,118 CROW STOMACHS EXAMINED.

NEMATODA.

Gordius sp.

ANNULATA.

Nereis sp. | *Lumbricus* sp.

CRUSTACEA.

Crangonyx sp.	*Porcellio* sp.	*Emerita talpoida.*
Armadillidium sp.	*Cambarus* sp.	

MYRIAPODA.

Julus cœruleocinctus. | *Polydesmus* sp.

INSECTA.

COLEOPTERA.

Cicindela punctulata.	*Tetracha virginica.*	*Anisodactylus rusticus.*
Cicindela purpurea.	*Agonoderus pallipes.*	*Anisodactylus sericeus.*
Cicindela repanda.	*Amara pennsylvanica.*	*Anisodactylus terminatus.*
Cicindela 6-guttata.	*Amara polita.*	*Anisodactylus verticalis.*
Cicindela scutellaris.	*Amara fallax.*	*Bembidium* sp.
Cicindela unipunctata.	*Anisodactylus agricola.*	*Brachynus sp.*
Cicindela vulgaris.	*Anisodactylus baltimorensis.*	*Calosoma calidum.*
Omus sp.	*Anisodactylus carbonarius.*	*Calosoma cancellatum.*

Calosoma externum.
Calosoma luxatum.
Calosoma scrutator.
Calosoma tepidum.
Calosoma willcoxi.
Carabus mœander.
Carabus serratus.
Carabus sylvosus.
Carabus vinctus.
Casnonia pennsylvanica.
Chlœnius æstivus.
Chlœnius impunctifrons.
Chlœnius laticollis.
Chlœnius nemoralis.
Chlœnius niger.
Chlœnius pennsylvanicus (?).
Chlœnius sericeus.
Chlœnius tomentosus.
Chlœnius tricolor.
Cratacanthus dubius.
Cychrus elevatus.
Cychrus marginatus (?).
Cychrus stenostomus.
Cymindis pilosa.
Dicœlus furvus.
Dicœlus purpuratus.
Elaphrus ruscarius.
Evarthrus sodalis.
Galerita lecontei.
Geopinus incrassatus.
Harpalus amputatus.
Harpalus basilaris.
Harpalus caliginosus.
Harpalus erraticus.
Harpalus herbivagus.
Harpalus lewisii.
Harpalus pennsylvanicus.
Harpalus vagans.
Harpalus viridiæneus.
Loxandrus sp.
Nothopus grossus.
Panagæus fasciatus.
Pasimachus depressus.
Pasimachus elongatus (?).
Pasimachus marginatus.
Pasimachus punctulatus.
Patrobus longicornis.
Platynus crenistriatus.
Platynus cupripennis.
Platynus cupreus.
Platynus melanarius.
Platynus punctiformis.
Pterostichus coracinus.
Pterostichus lucublandus.
Pterostichus patruelis.
Pterostichus sayi.
Pterostichus stygicus.
Scarites subterraneus.
Scarites substriatus.
Colymbetes sculptilis.
Cybister sp.
Dytiscus verticalis.
Rhantus binotatus.
Hydrobius globosus.
Hydrocharis obtusatus.
Hydrophilus triangularis.
Tropisternus glaber.
Tropisternus nimbatus.
Sphœridium scarabœoides.
Necrophorus americanus.
Necrophorus marginatus.
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Silpha americana.
Silpha inœqualis.
Silpha lapponica.
Silpha noveboracensis.
Silpha ramosa.
Silpha surinamensis.
Bledius sp.
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Lathrobium sp. (?).
Listotrophus sp.
Staphylinus cinnamopterus.
Staphylinus maculosus.
Staphylinus mysticus.
Staphylinus tomentosus.
Staphylinus viridans.
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Hister americanus.
Hister cognatus.
Hister depurator.
Hister fœdatus.
Hister instratus.
Hister merdarius.
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Byrrhus americana.
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Melanactes morio.
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Melanotus marginatus.
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Brachys ærosa.
Buprestis fasciata.
Buprestis striata.
Chalcophora virginiensis.
Chrysobothris femorata.
Dicerca obscura.
Dicerca lurida.
Photuris pennsylvanica.
Telephorus sp.
Collops sp.
Sitodrepa panicea.
Ceruchus piceus.
Dorcus parallelus.
Lucanus dama.
Passalus cornutus.
Anomala binotata.
Anomala lucicola (?).
Anomala varians.
Aphodius fimetarius.
Aphodius fossor.
Aphodius granarius.
Aphodius inquinatus.
Aphodius lividus.
Aphodius pardalis.
Aphodius ruricola.
Atœnius cognatus.
Atœnius cylindrus (?).
Bolboceras lazarus.
Bolbocerosoma farctum.
Canthon chalcites.
Canthon lœvis.
Canthon simplex.
Chœridium histeroides.
Copris anaglypticus.
Copris minutus.
Cotalpa lanigera.
Cotinis nitida.
Cremastochilus knochii.
Dialytes striatulus.
Dichelonycha albicollis (?).
Diplotaxis tristis.
Dynastes sp.
Dyscinetus trachypygus.
Euphoria fulgida.
Euphoria inda.
Euphoria sepulchralis.
Geotrupes balyi (?).
Geotrupes blackburnii.
Geotrupes egerei.
Geotrupes semiopacus.
Geotrupes splendidus.
Hoplia trivialis.
Pinotus carolinus.
Phyllophaga anxia.
Phyllophaga barda.
Phyllophaga crassissima.
Phyllophaga crenulata.
Phyllophaga drakii.
Phyllophaga fervida.
Phyllophaga forsteri.
Phyllophaga fraterna.
Phyllophaga fusca.
Phyllophaga futilis.
Phyllophaga hirsuta.
Phyllophaga hirticula.
Phyllophaga hornii.
Phyllophaga ilicis.
Phyllophaga implicita.
Phyllophaga marginalis.
Phyllophaga profunda.
Phyllophaga rubiginosa.
Phyllophaga rugosa.
Phyllophaga tristis.
Phyllophaga vehemens.
Ligyrus gibbosus.
Ligyrus relictus.
Macrodactylus subspinosus.
Ochodæus sp. (?).

Onthophagus hecate.
Onthophagus pennsylvanicus.
Osmoderma eremicola (?).
Pelidnota punctata.
Phanæus carnifex.
Polyphylla sp.
Serica vespertina.
Strategus antæus.
Trichius piger.
Trox asper.
Trox suberosus.
Xyloryctes satyrus.
Acmæops subpilosa.
Anthophilax malachiticus.
Clytanthus ruricola.
Desmocerus palliatus.
Distenia undata.
Leptura vittatus.
Monilema annulatum.
Monohammus scutellatus.
Monohammus titillator.
Tetraopes sp.
Toxotus cinnamopterus (?).
Toxotus schaumii (?).
Typocerus lunatus.
Calligrapha elegans.
Chætocnema denticulata (?).
Coptocycla sp.
Crepidodera helxines.
Donacia pulsilla (?).
Gyptoscelis sp. (?).
Myochrous denticollis.
Typophorus canellus.
Physonota unipunctata.
Systena elongata.
Spermophagus robiniæ.
Asida sp.
Coniontis ovalis.
Eleodes letcheri.
Eleodes tricostata.
Epitragus tomentosus.
Eusattus muricatus.
Helops cisteloides.
Opatrinus aciculatus.
Opatrinus notus.
Iphthimus opacus.
Meracantha contracta.
Paratenetus punctatus.
Cantharis sp.
Meloe angusticollis.
Thecesternus humeralis.
Anametis granulatus.
Epicærus imbricatus.
Eupagoderes sp.
Glaphyrometopus ornithodorus.
Hormorus undulatus.
Melamomphus luteus.
Otiorhynchus sulcatus.
Tanymecus confertus.
Chalcodermus æneus.
Conotrachelus posticatus.
Hylobius pales.
Hyperodes sp.
Lepyrus geminatus.
Listronotus appendiculatus.
Listronotus caudatus.
Lixus concavus.
Pachylobius picivorus.
Hypera punctata.
Rhyssematus lineaticollis.
Sitona flavescens.
Sitona hispidula.
Stephanocleonus plumbeus.
Tyloderma foveolatum.
Eupsalis minuta.
Sphenophorus cariosus.
Sphenophorus costipennis.
Sphenophorus germari.
Sphenophorus melanocephalus.
Sphenophorus parvulus.

ORTHOPTERA.

Arphia sp.
Chortophaga viridifasciata.
Dissosteira carolina.
Encoptolophus sordidus.
Gomphocerus clepsydra.
Hippiscus corallipes.
Melanoplus atlunis.
Melanoplus bivittatus.
Melanoplus differentialis.
Melanoplus femur-rubrum.
Schistocerca americana.
Stenobothrus sp.
Tettigidea sp.
Tettix granulata.
Tettix triangularis.
Anabrus simplex.
Ceuthophilus sp.
Conocephalus ensiger.
Cyrtophyllus perspicillatus.
Orchelimum sp.
Gryllotalpa borealis.
Gryllus assimilis.
Nemobius vittatus.

LEPIDOPTERA.

Epargyreus tityrus.
Cressonia juglandis.
Callosamia promethia.
Hemileuca maia.
Tropæa luna (?).
Adelocephala sp. (?).
Apantesis arge.
Diacrisia virginica.
Apatela oblinita.
Agrotis sp.
Feltia subgothica (?).
Alabama argillacea.
Cirphis unipuncta.
Laphygma frugiperda.
Nephelodes violans.
Datana sp. (?).
Crambus sp.
Hemerocampa leucostigma.
Malacosoma americana.
Paleacrita vernata.

HEMIPTERA.

Cicada pruinosa.
Tibicen septendecim.
Vanduzea sp.
Notonecta sp.
Belostoma sp.
Zaitha fluminea.
Pelocoris femoratus.
Apiomerus crassipes.
Fitchia aptera.
Melanolestes abdominalis.
Melanolestes picipes.
Arilus cristatus.
Sinea sp.
Ploiariola errabunda.
Gerris sp.
Blissus leucopterus.
Neides muticus.
Alydus eurinus.
Euthoctha galeator.
Acrosternum hilare.
Ælia americana.
Brochymena sp.
Euschistus servus.
Euschistus variolarius.
Hymenarcys nervosa.
Menecles insertus.
Podisus maculiventris.
Thyreocoris sp.

DIPTERA.

Limnobius sp.
Tipula sp.
Bibio femoratus (?).
Odontomyia sp.
Sargus sp.
Stratiomyia sp.
Tabanus atratus.
Sparnopolius fulvus (?).
Promachus rufipes.
Dolichopus sp. (?).
Gastrophilus sp.
Sarcophaga sp.
Calliphora vomitoria.
Lucilia cæsar.
Prochyliza sp.

HYMENOPTERA.

Lagium atroviolaceum.	*Formica pallide-fulva schaufussi.*	*Vespula maculata.*
Cimbex americana.	*Formica rufa obscuripes.*	*Cryptocheilus* sp.
Amblyteles sp.	*Formica truncicola integra.*	*Priocnemis* sp.
Ophion sp.	*Formica truncicola obscuriventris.*	*Psammochares* sp.
Aphœnogaster fulva.	*Lasius alienus.*	*Astata* sp.
Crematogaster lineolata.	*Lasius claviger.*	*Crabro* sp.
Messor sp.	*Lasius interjectus.*	*Halictus* sp.
Myrmica brevinodis.	*Mutilla* sp.	*Sphecodes* sp.
Myrmica rubra.	*Tiphia inornata.*	*Andrena* sp.
Solenopsis debilis.	*Scolia* sp. (?).	*Nomia* sp.
Tetramorium sp.	*Odynerus* sp.	*Nomada* sp.
Dolichoderes mariæ.	*Polistes metricus.*	*Megachile* sp.
Camponotus herculeanus pennsylvanicus.	*Polistes variatus* (?)	*Apis mellifera.*
Formica fusca subsericea.		

ODONATA.

Epiæscha heros (?).		

NEUROPTERA.

Corydalis cornutus.	*Chrysopa* sp.	*Myrmeleon* sp.

ARACHNIDA.

Dolomedes sp.	*Lycosa carolinensis.*	*Lycosa punctulata.*

MOLLUSCA.

Ostræa sp.	*Bulimus* sp.	*Polygyra tridentata.*
Eurynia parva.	*Helix* sp.	*Euglandina* sp.
Sphærium sulcatum.	*Polygyra dorfeuilliana sampsoni.*	*Gastrodonta suppressa.*
Amnicola limosa.	*Polygyra hirsuta.*	*Pyramidula perspectiva.*
Melampus bidentatus.	*Polygyra hopetonensis.*	*Bittium nigrum* (?).
Physa heterostropha.	*Polygyra inflecta.*	*Littorina rudis.*
Planorbis bicarinatus.	*Polygyra monodon.*	
Succinea avara.		

PISCES.

Cyprinus sp. (?).	*Notropis* sp.	*Lepomis* sp.
Hybopsis sp. (?).	*Semotilus* sp. (?).	

AMPHIBIA.

Bufo sp.	*Hyla* sp. (?).	*Rana* sp.

REPTILIA.

Sceloporus sp.	*Eutænia* sp.	
Zamenis constrictor.	*Diadophis punctatus.*	

AVES.

Bartramia longicauda.	*Melanerpes erythrocephalus.*	*Passerina cyanea* (?).
Bonasa umbellus.	*Sturnella magna* (?).	*Dumetella carolinensis.*
Colinus virginianus.	*Astragalinus tristis.*	*Planesticus migratorius.*
Gallus (domestic fowl).	*Melospiza melodia* (?).	*Sialia sialis* (?).

MAMMALIA.

Scalopus sp.	*Peromyscus leucopus.*	*Zapus hudsonius.*
Blarina brevicauda.	*Reithrodontomys* sp.	*Citellus tridecemlineatus.*
Microtus sp.	*Sigmodon hispidus.*	*Sylvilagus floridanus mearnsi.*
Mus musculus.	*Thomomys* sp.	
Rattus norvegicus.	*Geomys bursarius.*	

PLANTS.

Equisetum sp.
Pinus sp.
Juniperus virginiana.
Potamogeton sp.
Andropogon sorghum.
Avena sativa.
Bromus sp.
Chætochloa glauca.
Chætochloa viridis.
Echinochloa crus-galli.
Hordeum sativa.
Melica striata.
Panicum capillare.
Paspalum sp.
Syntherisma humifusa.
Triticum vulgare.
Zea mays.
Zizania aquatica.
Cyperus diandrus.
Eleocharis sp.
Peltandra sp.
Smilax rotundifolia.
Myrica carolinensis.
Myrica cerifera.
Castanea pumila.
Fagus americana.
Quercus sp.
Celtis sp.
Morus sp.
Fagopyrum fagopyrum.
Polygonum arifolium.
Polygonum convolvulus.
Polygonum hydropiper.
Polygonum lapathifolium.
Polygonum pennsylvanicum.
Polygonum persicaria.
Polygonum scandens (?).
Rumex acetosella.
Atriplex sp. (?).
Chenopodium album.
Chenopodium ambrosiodes.
Amaranthus blitoides.
Phytolacca decandra.
Portulaca oleracea.
Agrostemma githago.
Alsine media.
Vaccaria vaccaria.
Ranunculus sp.
Berberis vulgaris.
Brassica napus.
Ribes sp.
Fragaria sp.
Potentilla sp. (?).
Rosa sp.
Rubus strigosus.
Amelanchier canadensis.
Crataegus sp.
Malus malus.
Prunus avium.
Prunus pennsylvanica.
Prunus serotina.
Prunus (cultivated).
Prunus virginiana.
Medicago sp.
Melilotus sp.
Phaseolus sp. (?).
Trifolium pratense (?).
Vigna sinensis.
Oxalis stricta.
Rhus copallina.
Rhus glabra.
Rhus hirta (?).
Rhus radicans.
Rhus vernix.
Ilex opaca.
Berchemia scandens.
Ampelopsis cordata.
Parthenocissus quinquefolia.
Vitis cordifolia.
Malva sp.
Sida sp.
Lepargyrea argentea.
Lepargyrea canadensis.
Cornus alternifolia.
Cornus asperifolia.
Cornus florida.
Cornus occidentalis.
Cornus paniculata.
Cornus stolonifera.
Nyssa sylvatica.
Gaylussacia sp.
Oxycoccus oxycoccus.
Solanum carolinense.
Solanum dulcamara.
Solanum nigrum.
Solanum tuberosum.
Lithospermum sp.
Verbena sp.
Plantago lanceolata.
Diodia teres.
Galium aparine (?).
Mitchella repens.
Lonicera japonica.
Sambucus canadensis.
Sambucus pubens.
Symphoricarpos sp.
Viburnum dentatum.
Citrullus citrullus.
Cucumis melo.
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THE IDENTIFICATION OF VARIETIES OF BARLEY.

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VARIETIES OF BARLEY.

This bulletin has been prepared primarily to meet a widespread demand for a publication on the forms of barley. Although advantage has been taken of the opportunity to call attention to a number of new forms, the main object has been to satisfy the demand from experiment-station workers and advanced students in agronomy for an outline of the cultivated barleys. This demand can be traced to three causes—the many new forms of barley annually added to our collections, the broadening field of genetic and agronomic studies, and the confusion in and lack of availability of the literature on the forms of barley.

The increase in the number of barley varieties has been rapid. Not only have many new sorts been produced by the various agricultural experiment stations, but there has been a large number of importations. These importations have been of many types and of themselves have

done much to stimulate interest in barley. At the same time a demand for more detailed information on all our crops has developed. Plant problems, especially studies in variations and inheritance, are being persistently attacked. When this new interest was directed toward barley, it immediately became apparent that this crop, because of the unusual clearness of the varietal distinctions, was exceptionally well suited both to student instruction and to genetic studies. This clearness comes in part from the very broad limits of the group. The variable characters are numerous and the separations sharp. Few cultivated crops present such contrasts as hulled and naked kernels,[1] awned and hooded lemmas, fertile and infertile lateral florets, etc. The number of factors, coupled with the fact that all forms are perfectly fertile when crossed with each other, has resulted in a large number of easily distinguished varieties. The relative ease of subdividing the species makes the crop a profitable one to the student, and the definiteness of its varieties makes it equally useful to the plant breeder.

The lack of available literature and the confusion existing as to the identity of the various forms have been a real handicap to students and plant breeders alike. Studies in crop plants must include a comprehensive summary of the forms and types of each crop. This is a necessity for that familiarity with the crop which both student and agronomist should possess and is essential to a proper understanding of the publications of others dealing with the subject.

At present American literature contains no such summary. Indeed, the only work in English which attempts to present a complete arrangement of the forms is Beaven's "Variety of Barley" (1902).[2] This is out of print and is to be found in very few libraries. In French there are the works of Heuzé (1872, 1896–97), and in German those of Körnicke and Werner (1885), Voss (1885), and Atterberg (1899). The utilization of these and other more fragmentary publications is difficult. Frequently they are not available, and even if at the disposal of the investigator they present as many different methods of treatment as there are authors. In some instances the departures are so revolutionary that serious confusion has resulted.

The aims of this paper are (1) to coordinate the various schemes of classification and to reconcile them as far as possible, (2) to make available the work that has already been published on barley and to suggest modifications to obtain a more logical arrangement of the varieties, (3) to add the several new forms of barley which have been

[1] The word kernel is used throughout this publication to indicate the naked kernel (caryopsis) in the naked varieties and the kernel with lemma and palet attached (caryocist) in the hulled varieties. It was found too cumbersome to use the more limited terms, as they required repeated explanations.

[2] For complete citations, see "Literature cited," p. 31.

discovered during the progress of the work, and (4) to form the basis for a discussion of all the agricultural varieties grown upon the farms in America.

There is also a distinctly experimental phase to the work. Certain types of barley are likely to succeed in certain areas, while others are as definitely unsuited to specific regions. A more thorough coordination of the work of the various stations with reference to types of varieties should be of service in experimentation. It is possible also that a study of the existing forms of barley may be useful to pathologists in determining the degrees of immunity to disease of the various groups.

REVIEW OF THE LITERATURE.

Although the genus Hordeum to which the cultivated barleys belong obtains its name direct from the Latin name, there is little to be gained in a review of the literature before Linnæus. Almost all of the pre-Linnæan authors recognized the distinction between 2-rowed and 6-rowed barleys. Linnæus (1753, p. 84–85), amplifying his scheme of 1748, described six forms, four species and two varieties, viz:

Hordeum vulgare.
Hordeum vulgare coeleste.
Hordeum hexastichon.
Hordeum distichon.
Hordeum distichon nudum.
Hordeum zeocriton.

Gustav Schuebler (1818) named seven species, using in their separation fertility, color, adherence of flowering glumes, and density. In this work he made for the first time the distinction between *nutans* and *erectum*. These were subdivisions of *distichon* and not of the rank of the seven species.

Seringe (1819) suggested four species, *hexastichon*, *vulgare*, *zeocriton*, and *distichon*. In 1841 he followed closely the scheme of Linnæus, although he made several subdivisions.

Up to and including Seringe, all treatments were based upon limited collections. As a greater number of varieties were assembled, the problem of classifying them called for a marked expansion of the systems. The first of the more modern treatments was that of Heuzé in 1872. This was really a remarkable contribution, and in both arrangement and material was the obvious forerunner of both "Die Saatgerste" of Körnicke (1882) and of the treatment in the "Handbuch des Getreidebaues" of Körnicke and Werner (1885). "Die Saatgerste," as later amplified under the title of "Die Arten und Varietäten des Getreides" in the "Handbuch des Getreidebaues" (Bd. 1), has been widely accepted as the best modern authority. In part this credit is well bestowed. Körnicke used the variety as a unit, and although he sometimes went too much into

detail, his conception of varieties was such as to establish most of them upon a firm basis. His treatment of the larger groups, on the other hand, was less satisfactory. He recognized *hexastichon*, *tetrastichum*, *intermedium*, and *distichum* as his primary groups. These are more fully discussed later. A third paper appeared in 1895, and in 1908, after his death, his son, M. Körnicke, published a fourth treatment. Neither of these latter possesses the clearness of the earlier papers, and they include many doubtful varieties. Many of the additions were of hybrid origin and were unfixed at the time of publication. Körnicke's failure in many instances was due to the general lack of genetic information at that time. Recent discoveries have made the purification of a type rather simple. For instance, his *subcornutum* was selected from a mating of *trifurcatum* and *steudelii* and was far from fixed. A constant variety of this type is readily obtained from a cross of *cornutum* × *pallidum* or of *horsfordianum* × *haxtoni*. Many varieties attributed to Körnicke in the key which follows were heterozygous forms with him which he was never able to fix. Most of these have been recognized in this publication, because fixed forms corresponding to the descriptions have since been produced.

In 1885, the year in which the "Handbuch des Getreidebaues" was published, a paper by Voss appeared. Voss follows Jessen (1855) and places all cultivated barleys under the single species *Hordeum sativum*. Although his handling of the varieties is inferior to that of Körnicke, his treatment of the larger groups is decidedly better. He uses *polystichon*, *distichon*, and *deficiens* as his subspecies. He indicates that *deficiens* is subject to the same variations as *distichon* by subdividing it into dense and lax divisions. He substitutes *inequale* for the term *tetrastichum* of Körnicke, pointing out that there is no such thing as a 4-rowed barley.

Following Voss came Atterberg, who published various papers between 1889 and 1899. In the latter year he advanced a new basis of classification. He made four subspecies under *Hordeum sativum* Jess., namely, *commune*, *macrolepis*, *furcatum*, and *inerme*. As both the character of the outer glumes and the appendages to the lemma were used, the result was rather involved and seems to offer little compensation for so abrupt a departure. Atterberg's conception of the regular occurrence of the subfactors through each of the groups gives evidence of a familiarity with a larger number of varieties than had been accessible to previous taxonomists. His system of uniform recurrence of names in his subgroups seems inadvisable and likely to lead to confusion, even though, as he points out, he uses only 33 terms to designate 188 forms, while Körnicke used 78 terms to designate 74 varieties.

Beaven in 1902 published a paper which is the most complete arrangement of barley varieties in English. He used *vulgare* in the place of the *tetrastichum* of Körnicke, divided *distichon* into dense and lax subdivisions, using *zeocriton* and *distichon* as parallel terms to *hexastichon* and *vulgare*, and classed all deficient barleys under *decipiens*. He included 45 new varieties produced by Karl Hansen. In several instances they were not sufficiently described to determine their exact character. The doubtful varieties are of necessity omitted from this paper.

The work of Regel (1906, 1908, 1910) shows more originality and less of compilation than that of most of his contemporaries. In various articles appearing in the Bulletin der Bureau für angewandte Botanik and elsewhere, he has made unquestioned contributions to the knowledge of barley. In his later publications Regel has made his finer divisions upon what might be described as ecological races, such as the Chevalier, as contrasted with the Moravian barleys. Ther is very good reason for taking this position, in that it is much less arbitrary in its relations than the usual taxonomic distinctions. It has, however, two weaknesses. Such forms, being very difficult to separate under some conditions, can be utilized only by those who have made a special study of barley, and they have no limitation to their increase in number. Almost any new barley calls for a new division, whereas under the system proposed by the present writer most additions at least will fall in a group already established. The idea of geographic forms had perhaps best be carried out as an agronomic rather than a taxonomic project. In his broader divisions Regel has combined many previously described varieties and thus broadened the terms somewhat. His modifications are well founded. He recognizes only two densities instead of three, places the smooth-awned forms under their nearest rough-awned relatives, and considers blue and purple as forms of the white variety. Carleton's (1916) major groups of *polystichon*, *distichum*, and *intermedium* differ only in the rank of the deficient barleys from the scheme proposed in this bulletin.

VARIABLE FACTORS IN CULTIVATED BARLEY.

In cultivated barleys there are six variable characters which have been used in the description of varieties. These are fertility, adherence or nonadherence of the flowering glume, the character of the outer glumes, the character of terminal appendages to the lemma when present, color, and density. Of these, the adherence of the flowering glume and the character of the outer glumes have two conditions, the terminal appendages of the lemma and density have three conditions, and fertility and color have four conditions each. One

division of the appendages to the lemma and one of the outer glumes have been again separated into two subdivisions. The resulting number of possible varieties is in consequence very large.

FERTILITY.

Barley, being a typical Hordeum, produces three single-flowered spikelets at each node of the rachis. In the 6-rowed forms, all three of these are fertile. In the 2-rowed only the central spikelet of each three is fertile. There are four degrees of fertility, two in the 6-rowed and two in the 2-rowed forms. The four divisions are based upon characters of the lateral florets, the central floret being the same in all. The lateral florets of normal 6-rowed barleys are completely fertile and awned or hooded. The common 2-rowed barleys are characterized by sterile lateral florets, which are awnless and normally rounded at the tip. In the intermediate barleys the side florets are fertile, but the resulting kernels are usually small and the tips are without awns. Ordinarily the lemmas are rounded, but occasionally they bear bristlelike projections. In most varieties of this group only part of the lateral florets are fertile. The fourth division is distinguished from the common 2-rowed form by a still further reduction of the side florets. This reduction may be carried to the point where only a single outer glume is present. Usually the spikelets are represented only by the outer glumes and rachilla, the floral glumes and sexual organs being entirely aborted. In some strains the lemma is present, and in a very few there are traces of the palet. Rudimentary ovaries and stamens are never found. Barleys in which sterile ovaries, rudimentary stamens, or well-developed palets appear are classed as normal 2-rowed forms.

ADHERENCE OF THE FLOWERING GLUME.

The distinction between adherent and nonadherent flowering glumes is the sharpest and most easily determined of the six. It separates the barleys into the hulled and naked forms. In the hulled varieties the ovary grows fast to the lemma shortly before maturity. In the naked sorts this union does not take place, and when the spikes are thrashed the kernel thrashes free from the glume, as in wheat.

OUTER GLUMES.

Each floret in barley is subtended by a pair of outer glumes. These are normally narrow, lanceolate bracts, with short, bristlelike awns. In rare cases they are expanded and the length of the awn increased. Those varieties with wide outer glumes have been further separated by some authorities, because in some instances all six of the outer glumes at a node are widened, whereas in other cases only the two

outermost of the six are so expanded. The expanded outer glume is a rare variation, which may be disregarded from an agricultural standpoint, as no such varieties are cultivated commonly.

TERMINAL APPENDAGES OF THE LEMMA.

The lemma of either central or lateral spikelets may terminate in an awn or hood, or it may be merely rounded or pointed at the tip without either awn or hood. The hooded barleys usually are referred to in this country as beardless. Since there are true awnless sorts the term awnless is here used for these rare varieties and the term hooded for all varieties with hoods. The use of the term beardless, which is easily misunderstood, is thus avoided. The hooded varieties all appear to trace their origin to the Nepal barley. In this variety the awn is replaced by a trifurcate appendage, the three lobes of which are a partial duplication of the three florets at a node of the rachis. These monstrous florets often bear fertile stamens and are said sometimes to produce seed.

In the hooded barleys two minor separations have been made. The normal hood, as in the Nepal barley, is sessile. In many hybrids the hood is elevated more or less on an awn. Variations in the small awns sometimes produced by the hood also have been noted.

The awns of barley may be either rough or smooth. They are normally very scabrous, being much rougher than those of wheat. In a few potentially valuable agronomic forms the awns are smooth or slightly roughened at the tip. They are, however, entirely smooth toward the base, where the largest teeth are found in the rough-awned varieties. There are also a number of minor forms which bear awns considerably shorter than the normal. In others, the awn is malformed, being flattened or twisted. The difficulty of using either of these latter distinctions in other than an agronomic way is at once apparent, the one being a merging character and the last an abnormality.

COLOR.

Four color conditions have been recognized in barley varieties. In the hulled varieties the distinction is based upon pigments located in the lemma and such aleurone and other colors as may show through the more or less translucent lemma. The naked varieties are separated on pigments found in the caryopsis, disregarding entirely the character of the lemma. In the hulled varieties the first color division is that in which no pigment is present. This results in a white or yellow barley. The second and third divisions, blue and purple, as previously pointed out (Harlan, 1914, p. 30), probably are related. The blue varieties of hulled barley come from a blue aleurone layer showing through the superimposed lemmas.

The purple colors are in the glumes themselves. The black colors come from a melaninlike pigment, which in the hulled varieties occurs in the lemmas. This may exist in different degrees and has been used to subdivide black barleys, although the advisability of separating on degree is questionable.

In the naked varieties the colors are determined more easily. The absence of pigment results in a white or yellowish grain, as in the hulled. The blue colors are located in the aleurone layer. In mature specimens they are unmistakable; in immature ones the color is slight and may give only a bluish cast, as it is deposited late in the development of the kernel. In the white varieties immaturity may result in a greenish appearance which might be confused with immature blue kernels. The purple color results from a blue aleurone layer beneath a red pericarp. In all purple varieties at present known the color is well developed except in very immature specimens and can be determined without difficulty. Black naked varieties with a true melanin pigment are very rare. Purple naked ones are usually referred to as black, although in reality they contain no black pigment and are separated easily from those having the black pigment.

DENSITY.

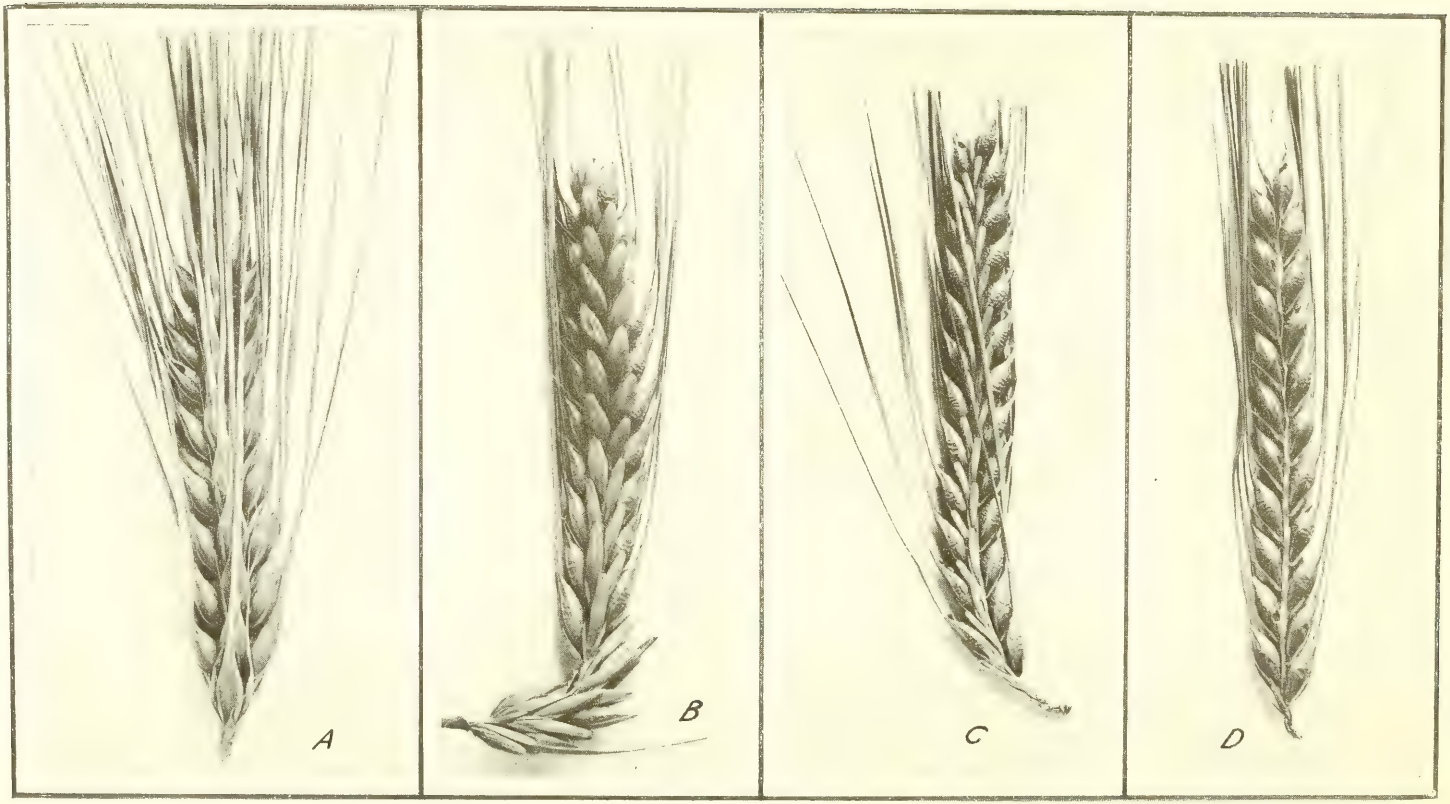
Density unfortunately has been used as a major distinction in the classification of barley and usually has been confused with fertility. This is the most unsatisfactory of all the six characters. The behavior of hybrids indicates that density is determined by heritable factors, however, and further information upon its behavior may increase greatly its value as an agronomic character useful in the description of biotypes. As may be seen in Plate I, in typical forms, such as Peacock, Plumage, and Hanna, representing *zeocriton*, *erectum*, and *nutans*, respectively, the differences are marked. The intergradations are so numerous and so complete that any broad application results in confusion. Statements in taxonomic publications on barley indicate that all investigators have had great difficulty in making satisfactory separations. The groups have been divided into dense and lax varieties. In some cases the dense varieties have been further subdivided into dense and very dense groups. Körnicke in some of his treatments has divided even the very dense into two subdivisions. Such confusion is inevitable wherever separations are made upon degree, and the use of density has been confined in this paper to the description of subvarieties.

SCHEME OF CLASSIFICATION.

A very superficial survey of the combinations that are possible with the variable factors just described is sufficient to indicate the scope

Spikes of Three Varieties of 2-Rowed Barley, Showing Three Degrees of Density Commonly Recognized.

A, Peacock (*zeocriton*); *B*, Plumage (*erectum*); *C*, Hanna (*nutans*).



TYPICAL SPIKES OF THE FOUR SPECIES OF CULTIVATED BARLEY.

A, Hordeum vulgare; B, Hordeum intermedium; C, Hordeum distichon; D, Hordeum deficiens.

of the problem to be solved. When it is realized that a great number of these forms are known and that there is no reason why all of them can not be produced, or indeed may not be found already in existence in some part of the world, the futility of continuing the policy of describing each minor variation becomes apparent. In fact, there is more to be done than merely resolving not to add to the confusion. Over 200 forms have been named and described. Some semblance of order must be brought about in the work already published and some constructive plan suggested whereby future additions may be limited to variations of real importance. When the variable characters are studied carefully with this object in view, it soon becomes apparent that the factors are not all of the same value.

The fertility and the adherence or nonadherence of the lemmas are major distinctions. They seldom present any difficulties. The nature of the appendages of the flowering glume are major distinctions so far as the distinctions between awns and hoods are concerned. The presence or absence of hoods is obvious. In the separation of varieties the term "awned" has been made to include awnless and all intergradations, as a complete series from awnless to fully awned seems likely to exist. White and black kernels are also major distinctions. White has been used to include blue and purple, because of the frequently imperfect production of the latter pigments and the difficulty of determining doubtful varieties. By using only these four groups, the varieties are founded upon distinct and readily separable characters. Each variety is then a specific, tangible group.

As lesser but still usable distinctions there are the awnless and smooth-awned variations of the awned form, the blue and purple variations of white, and the character of the outer glumes.

Besides these, a considerable number of characters have been used in establishing varieties which in the light of present information seem unsuited as bases for taxonomic groups. In many instances they are very useful in agronomic work in the description of biotypes and in the identification of farm varieties, but they are not here recognized. Varieties which have been established upon these characters will be found only in the alphabetical list of rejected forms. These characters will not be discussed individually, but will be found listed in the summary below.

To summarize the variations, the three grades of distinction are as follows:

Major distinctions useful in establishing species and varieties:

Spikes 6-rowed, intermediate, 2-rowed, and deficient.
Kernels hulled and naked.
Lemmas awned (including awnless) and hooded.
Kernels white (including blue and purple) and black.

Minor distinctions useful in describing subvarieties:

Outer glumes wide and narrow.
Lemmas awnless and smooth awned as variations of awned.
Kernels blue and purple as variations of white.

Minor distinctions which are best used in describing agronomic biotypes (varieties founded on these are here disregarded except in the alphabetical list):

Only two outermost glumes expanded as a variation of wide outer glumes.
Elevation of the hood on a short awn.
Small awns arising from the hood.
Flattened or twisted malformations of the awn.
Short awns, except as noted in awnless.
Character of the hairs of the rachilla.
Scabrousness of the nerves of the lemma.
Proliferation of the spike.

THE SPECIES OF CULTIVATED BARLEY.

The species are of necessity based on fertility. This is predetermined essentially by the work already published, fertility having been used as a basis of separation since the earliest observations on barley.

There is no such unity of opinion in fixing the number of species. Some favor placing all cultivated barleys under a single species, as did Jessen (1855). To the writer, on the other hand, the group seems too broad to be so united. Clearness is better served by making the species a smaller unit. Certainly no group of wild plants of such variation is united under a single species, and there is abundant evidence in the behavior of hybrids that at least two parents were involved in the production of the forms now domesticated. If fertility is to be subdivided there are three bases upon which it can be accomplished. Many of the earlier writers recognize only two divisions, 2 rowed and 6 rowed. Among the modern investigators Regel takes this view. This has the disadvantage of throwing the hybrid intermediate forms with the 6-rowed, when physiologically the indications are that they are nearer the 2-rowed forms. The only way to avoid this complication is to recognize the hybrid species *intermedium* of Körnicke. We then have three grades of fertility. There are actually, however, four conditions. In one group of Abyssinian 2-rowed barley the lateral spikelets are rudimentary. Although this distinction is not as sharp as the others and needs a larger collection of Abyssinian material to determine its status clearly, there is no justification at present for rejecting the character. If three conditions are recognized, the fourth should be, which means the acceptance of the division *deficiens* as equal in value to *distichon* and *vulgare*, as suggested by Voss (1885).

The four species, *vulgare*, *intermedium*, *distichon*, and *deficiens*, shown in Plate II, seem best to represent the differences as they exist. It is not to be assumed that this is the only method of separation which might be made on the basis of fertility. Genetically the pointed or rounded nature of the lateral floret may be correlated with the true relationship of the varieties, but it would be practically impossible to use this distinction in the *deficiens* group. Neither does it fit in with work already done. On the other hand, the species founded upon fertility alone require little modification of existing schemes. As has been noted previously, many taxonomists in the past have combined and even confused fertility with density. The work of Körnicke well illustrates this point. As Körnicke is the most widely known of the investigators who have combined the two characters, his scheme is represented graphically in Table I.

TABLE I.—*Scheme of classification of barley founded upon both fertility and density.*

[Terms in italic represent Körnicke's major groups.]

- *H. vulgare*
  - polystichum
    - normal 6-rowed
      - *hexastichum*
        - very dense.
        - dense.
      - *tetrastichum*.
    - *intermedium*
      - dense.
      - lax.
  - *distichum*
    - normal 2-rowed
      - dense
        - very dense.
        - dense.
      - lax.
    - deficient 2-rowed.

It will be noted that Körnicke's major groups have very little relation to each other. Beaven (1902) remedied this defect to some extent by carrying over *zeocriton* to designate the dense normal 2-rowed, *distichon* to represent the lax, and *decipiens* to designate the deficient 2-rowed barley. His grouping, however, was not on equal separations, in that the *intermedium* and *decipiens* were separated further into dense and lax, which separations are parallel with his *zeocriton*, *distichon*, *vulgare* (*tetrastichum* Kcke.), and *hexastichon*. Although the system of Beaven was an improvement in a way, it still maintained the objectionable principle of combining the characters of density and fertility.

When the present work was begun it was thought that it would be almost impossible to maintain these well-established distinctions. However, by eliminating the density factor and retaining only the question of fertility, the four species already mentioned were obtained. This scheme is graphically represented in Table II.

TABLE II.—*Scheme of classification of barley founded upon fertility, eliminating density.*

Genus.	Section.	Subsection.	Species.
Hordeum	vulgare	Eu. vulgare	vulgare.
		intermedium	intermedium.
		distichon	distichon.
			deficiens.

KEY TO THE SPECIES.

The meaning of the graphic representation is made somewhat clearer by consulting the key to the species. It will be noted that the absence of appendages on the lateral florets is used to separate the species *intermedium*. This distinction is in reality one of fertility, the most obvious indication of which is the absence of appendages on the lemma. These lateral florets are probably not comparable to the lateral florets of *vulgare* but to the lateral florets of *distichon*, differing from the latter in having become fertile.

Key to the species.

All spikelets fertile (6-rowed barley).
- Lemmas of all florets awned or hooded ——— *vulgare* L.
- Lemmas of lateral florets bearing neither awns nor hoods. *intermedium* Kcke.

Only the central spikelets fertile (2-rowed barley).
- Lateral spikelets consisting of outer glumes, lemma, palet, rachilla, and usually rudiments of the sexual organs ——— *distichon* L.
- Lateral spikelets reduced, usually to only the outer glumes and rachilla, rarely more than one flowering glume present, and never rudiments of sexual organs ——— *deficiens* Steud.

Of these species the first three present no nomenclatural difficulties. *Vulgare* and *distichon* trace direct to Linnæus (1753), and *intermedium* to Körnicke (1882, p. 125). In the fourth there is more question of priority. According to Körnicke and Werner (1885), Steudel described *deficiens* in 1842. Apparently there was no published description, the identification being only the name written on a herbarium sheet of Schimper's Abyssinian collection. The name first applied appears to have been *decipiens* and not *deficiens*. In 1854 (p. 351) Steudel gives a very complete description of *deficiens* as a species. So far as the writer can learn, this is the first time the name was used in print. In May, 1842, Seringe (p. 194) in additions to the genus Hordeum describes all the common forms of deficient barley under the variety *abyssinicum*.

In the key the only question arises in the separation of the deficient 2-rowed from the normal 2-rowed barleys. Deficient types are

uncommon, and deficient barleys which show intergradations toward the normal 2-rowed are rare indeed.

In the 6-rowed barleys all awnless forms are thrown into *intermedium*. The awnless character is most probably of hybrid origin, and in all 6-rowed awnless varieties now known there is a tendency in some strains to produce short awns on the central spikelets when grown under especially favorable conditions, indicating a direct relationship with *intermedium*. It may be found necessary to include awnless sorts under *Hordeum vulgare* as well, but at present it seems better to list these forms with the *intermedium*.

Of the varieties and subvarieties which follow, a large number are of hybrid origin. The species *intermedium* probably consists entirely of hybrid varieties. In the beginning it was attempted to separate the known hybrid varieties from those occurring naturally. However, there seems no good reason for such a distinction, for many of the varieties which are not known to be hybrid probably have arisen from accidental crossing.

For example, the variety *horsfordianum* was named for a Mr. Horsford in Vermont, who crossed a Nepal (6-rowed hooded naked) on a 6-rowed bearded hulled and obtained a 6-rowed hooded hulled. This variety is grown extensively in the United States and is absolutely constant. It is inconceivable that all barley of this description in this country and elsewhere came from Mr. Horsford's cross. The Nepal has been grown in India alongside of hulled varieties for centuries, and the cross must have occurred time and again naturally, despite the fact that barley is one of the most closely fertilized of plants. It is a strange coincidence that the only natural hybrid that has occurred in the nursery in the six years of this investigation was between the Nepal and a 6-rowed bearded hulled variety, from the progeny of which a Horsford type has been isolated.

In describing varieties, fertility having been used as a specific distinction, there remain hulled or naked kernels, awned (including awnless) or hooded lemmas in the central spikelet, and white (including blue and purple) or black color as major distinctions. The first two of these characters, with the variation in width of the outer glumes later spoken of in the discussion of subvarieties, are shown in Plate III. The regularity of the gradation in differences between the varieties in each group is sufficient to excite the suspicion of the taxonomist, because such uniformity is not common in nature. Ordinarily, variations do not occur in a closely graded series. Neither did they in barley at first, but continued crossing, natural and artificial, has slowly filled the gaps.

Hordeum vulgare trifurcatum, for example, at first stood off clearly as the trifurcate naked 6-rowed barley. Then *horsfordianum* was produced and there were two trifurcate 6-rowed sorts, one hulled

and the other naked. Later, the trifurcate character was transferred to many forms, until *H. v. trifurcatum* is noteworthy only as the parent form of trifurcate barleys. This illustrates the vital difference between the treatment of a group with only a few representatives and one with many. The greater the number of forms, the fewer are the characters that separate them.

KEY TO THE VARIETIES.

Following is the key to the varieties occurring under the four species of barley:

Hordeum vulgare. Barleys with three fertile spikelets at each node, the lemmas of both central and lateral florets bearing awns or hoods.
- Kernels hulled.
  - Lemmas awned.
    - Kernels white, blue, or purple ..... 1. *pallidum.*
    - Kernels black ..... 2. *nigrum.*
  - Lemmas hooded.
    - Kernels white, blue, or purple ..... 3. *horsfordianum.*
    - Kernels black ..... 4. *atrum.*
- Kernels naked.
  - Lemmas awned.
    - Kernels white, blue, or purple ..... 5. *coeleste.*
    - Kernels black ..... 6. *duplinigrum.*
  - Lemmas hooded.
    - Kernels white, blue, or purple ..... 7. *trifurcatum.*
    - Kernels black ..... 8. *aethiops.*

Hordeum intermedium. Barleys in which the lateral florets are fertile but awnless.
- Kernels hulled.
  - Lemma of central floret awned or awnless.
    - Kernels white, blue, or purple ..... 9. *haxtoni.*
    - Kernels black ..... 10. *mortoni.*
  - Lemma of central floret hooded.
    - Kernels white, blue, or purple ..... 11. *subcornutum.*
    - Kernels black ..... 12. *atricornutum.*
- Kernels naked.
  - Lemma of central floret awned or awnless.
    - Kernels white, blue, or purple ..... 13. *nudihaxtoni.*
    - Kernels black ..... 14. *nudimortoni.*
  - Lemma of central floret hooded.
    - Kernels white, blue, or purple ..... 15. *cornutum.*
    - Kernels black ..... 16. *subaethiops.*

Hordeum distichon. Barleys in which the lateral florets are present but sterile.
- Kernels hulled.
  - Lemmas awned or awnless.
    - Kernels white, blue, or purple ..... 17. *palmella.*
    - Kernels black ..... 18. *nigricans.*
  - Lemmas hooded.
    - Kernels white, blue, or purple ..... 19. *angustispicatum.*
    - Kernels black ..... 20. *rimpaui.*

Hordeum distichon—Continued.
Kernels naked.
Lemmas awned or awnless.
Kernels white, blue, or purple—— 21. *nudum.*
Kernels black—— 22. *nigrinudum.*
Lemmas hooded.
Kernels white, blue, or purple—— 23. *laxum.*
Kernels black—— 24. *nigrilaxum.*

Hordeum deficiens. Barleys in which the lateral florets are not only sterile but rudimentary.
Kernels hulled.
Lemmas awned or awnless.
Kernels white, blue, or purple—— 25. *deficiens.*
Kernels black—— 26. *steudelii.*
Lemmas hooded.
Kernels white, blue, or purple—— 27. *triceros.*
Kernels black—— 28. *tridax.*
Kernels naked.
Lemmas awned or awnless.
Kernels white, blue, or purple—— 29. *nudideficiens.*
Kernels black—— 30. *decorticatum.*
Lemmas hooded.
Kernels white, blue, or purple—— 31. *sublaxum.*
Kernels black—— 32. *gymnospermum.*

The 32 varieties described above are thought to constitute the major variations in barley. It is possible that a group of Abyssinian barleys may later be added to the intermediate forms, but it is hoped that this may be avoided. In the list of subvarieties which follows there have been no additions, although many new sorts are available. It is thought best not to add to this list of named sorts, as the large number of names is already confusing. The list of subvarieties is made up entirely of forms that have been published as varieties, but which are little more than variations of an established type. As these names have been used and as the distinctions have some foundation, even though often a fragile one, it is necessary to indicate the group each was intended to describe. It can not be too strongly recommended, however, that additions be made to the list of subvarieties only when the value of the addition is above question. At the present time the writer has in his possession blue, purple, and smooth-awned variations in a large number of new combinations. A dense form of *tonsum* has been received recently from Japan. Many dense forms of deficient barleys have been isolated from Abyssinian barley, with a complete series of colors. The addition of these to the named subvarieties seems to offer no advantages, and when they are described it will be only in a list of agronomic varieties which is expected to supplement the present publication.

KEY TO THE SUBVARIETIES.

1. *Hordeum vulgare pallidum* Seringe (1841, p. 346).
   - Outer glumes narrow.
     - Kernels white.
       - Awns rough.
         - Spike narrow, lax, nodding——*typica.*
         - Spike wide, dense, the edges parallel; awns not widely spreading——*parallelum* Körnicke (as var., 1882, p. 166).
         - Spike wide, very dense, pyramidal, awns widely spreading. *pyramidatum* Körnicke (as var., 1882, p. 164).
       - Awns smooth.
         - Spike narrow, lax, nodding. *rikotense* Regel (as var., 1908, p. 74).
     - Kernels bluish.
       - Awns rough.
         - Spike narrow, lax, nodding. *coerulescens* Seringe (as var., 1841, p. 347).
     - Kernels purple.
       - Awns rough.
         - Spike narrow, lax, nodding. *subviolaceum* Körnicke (as var., 1895, p. 9).
   - Outer glumes wide.
     - Kernels white.
       - Awns rough.
         - Spike narrow, lax, nodding. *latiglumatum* Körnicke (as var., 1895, p. 9).
         - Spike wide, dense, erect. *eurylepis*, Körnicke (as var., 1882, p. 167).
2. *Hordeum vulgare nigrum* Willdenow (as sp., 1809, p. 1037).
   - Outer glumes narrow.
     - Awns rough.
       - Spike narrow, lax, nodding——*typica.*
       - Spike wide, dense, erect. *sehimperianum* Körnicke (as var., 1882, p. 165).
     - Awns smooth.
       - Spike narrow, lax, nodding. *leiorrhynchum* Körnicke (as var., 1882, p. 178).
   - Outer glumes wide.
     - Awns rough.
       - Spike narrow, lax, nodding. *atrospicatum* Körnicke (as var., 1895, p. 9).
       - Spike wide, dense, erect——*platylepis* Körnicke (as var., 1895, p. 9).
3. *Hordeum vulgare horsfordianum* Wittmack (1884).
   - Outer glumes narrow.
     - Kernels white.
       - Spike narrow, lax, nodding——*typica.*
       - Spike wide, dense, erect. *hexasticofurcatum* K. H. in Beaven (as var., 1902, p. 577).
4. *Hordeum vulgare atrum* Körnicke (1895, p. 9).
   - Outer glumes narrow.
     - Spike narrow, lax, nodding——*typica.*
     - Spike wide, dense, erect. *densifurcatum* K. H. in Beaven (as var., 1902, p. 577).

5. *Hordeum vulgare coeleste* Linnæus (as sp., 1753, p. 85).
   Outer glumes narrow.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding---------- *typica.*
            Spike wide, dense, the edges parallel, awns not widely spreading------ *revellatum* Körnicke (as var., 1882, p. 167).
            Spike wide, very dense, pyramidal, awns widely spreading. *nudipyramidatum* Körnicke (as var., 1895, p. 9).
      Kernels blue.
         Awns rough.
            Spike narrow, lax, nodding.
               himalayense Rittig (as var., 1822, according to Roemer and Schultes, 1824, p. 481).
      Kernels purple.
         Awns rough.
            Spike narrow, lax, nodding. *violaceum* Körnicke (as var., 1882, p. 183).
   Outer glumes wide.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding. *sublatiglumatum* Körnicke (as var., 1908, p. 425).
6. *Hordeum vulgare duplinigrum* Körnicke (1895, p. 9; modified, 1908, p. 424).
   Outer glumes narrow.
      Awns rough.
         Spike narrow, lax, nodding---------- *typica.*
7. *Hordeum vulgare trifurcatum* Schlechtendahl (1837, p. 543).
   Outer glumes narrow.
      Kernels white.
         Spike narrow, lax, nodding---------- *typica.*
8. *Hordeum vulgare aethiops* Körnicke (1895, p. 10).
   Outer glumes narrow.
      Spike narrow, lax, nodding---------- *typica.*
9. *Hordeum intermedium haxtoni* Körnicke (1882, p. 185).
   Outer glumes narrow.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding---------- *typica.*
            Spike wide, dense, the edges parallel; awns not widely spreading---------- *transiens* Körnicke (as var., 1882, p. 185).
            Spikes wide, very dense, pyramidal, awns widely spreading. *pavoninum* Körnicke (as var., 1908, p. 429).
         Lemma of central floret awnless. *tonsum* Körnicke (as var., 1908, p. 426).
10. *Hordeum intermedium mortoni* Körnicke (1908, p. 429).
    Outer glumes narrow.
       Awns rough.
          Spike narrow, lax, nodding---------- *typica.*
       Lemma of central floret awnless. *nigritonsum* Körnicke (as var., 1908, p. 426).

11. *Hordeum intermedium subcornutum* Körnicke (1908, p. 425).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding---*typica.*
Spike wide, dense, erect.
anomalum Körnicke (as var., 1895, p. 10; and 1908, p. 430).
12. *Hordeum intermedium atricornutum* Körnicke (1908, p. 425).
Outer glumes narrow.
Spike narrow, lax, nodding---*typica.*
13. *Hordeum intermedium nudihaxtoni* Körnicke (1908, p. 429).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding---*typica.*
Spike wide, dense, erect.
nuditransiens Körnicke (as var., 1908, p. 430).
Lemma of central floret awnless.
nuditonsum Körnicke (as var., 1908, p. 426).
14. *Hordeum intermedium nudimortoni* var. novo. This variety was selected from the progeny of a hybrid of *haxtoni* and *nigrinudum*. It is constant, and with the other new forms described later is included here in order that the list of principal varieties may be complete. It is a variety of *intermedium* with black, naked kernels, lemmas of the central florets awned, outer glumes narrow, and spike lax and nodding.
15. *Hordeum intermedium cornutum* Schrader (1838, p. 471).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding---*typica.*
Spike wide, dense, erect.
gymnanomalum Körnicke (as var., 1908, p. 430).
16. *Hordeum intermedium subaethiops* Körnicke (1908, p. 425).
Outer glumes narrow.
Spike narrow, lax, nodding---*typica.*
17. *Hordeum distichon palmella* var. novo. In the common 2-rowed barleys there has apparently been no name used in recent years to include *zeocriton*, *erectum*, and *nutans*. Each of these has such a definite and specific use as a subvarietal name that it can hardly be used to include the others. Jean des Moulins in 1615, in the French edition of the work of Dalechamps (p. 333), divided the barleys into two species, *polystichon* and *distichon*. The latter he called *pomole*. Olivier de Serres, writing the same year (p. 99), used the terms *paumes* and *paumoules* for the same barleys. The *pomole* of that date was nearly identical with the group here designated *palmella*. *Pomole*, with various spellings, as *paumoule*, *pamelle*, etc., is still applied popularly to the common 2-rowed barleys in France. The name *palmella* is here used in preference, as the Latin equivalent of palm, or little palm, doubtless referring to the appearance of the spike.
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
nutans Schuebler (as var., 1818, p. 36).
Spike wide, dense, the edges parallel; awns not widely spreading---*erectum* Schuebler (as var., 1818, p. 36).
Spikes wide, very dense, awns widely spreading.
zeocriton Linnæus (as sp., 1753, p. 85).

17. *Hordeum distichon palmella*—Continued.
Outer glumes narrow—Continued.
Kernels white—Continued.
Awns smooth.
Spike narrow, lax, nodding.
rigens K. H. in Beaven (as var., 1902, p. 578).
Awns wanting——*inerme* Körnicke (as var., 1895, p. 8).
Kernels bluish.
Awns rough.
Spike narrow, lax, nodding.
canescens K. H. in Beaven (as var., 1902, p. 578).
Awns smooth.
Spike narrow, lax, nodding.
medicum Körnicke (as var., 1882, p. 195).
Kernels purple.
Awns rough.
Spike narrow, lax, nodding.
hypianthinum Körnicke (as var., 1895, p. 10).
Outer glumes wide.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
dubium Körnicke (as var., 1908, p. 431).
Spike wide, dense, erect.
macrolysis K. H. in Beaven (as var., 1902, p. 578).
18. *Hordeum distichon nigricans* Seringe (1842, p. 357).
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding——*typica.*
Spike wide, dense, the edges parallel, awns not widely spreading.
contractum Körnicke (as var., 1882, p. 198).
Spike wide, dense, erect, awns widely spreading.
melanocrithum Körnicke (as var., 1882, p. 200).
Awns smooth.
Spike narrow, lax, nodding.
persicum Körnicke (as var., 1882, p. 196).
Awns wanting.
decussatum Körnicke (as var., 1895, p. 8).
Outer glumes wide.
Awns rough.
Spike narrow, lax, nodding.
braunii Körnicke (as var., 1882, p. 202).
Spike wide, dense, erect.
mixtum K. H. in Beaven (as var., 1902, p. 578).
19. *Hordeum distichon angustispicatum* Körnicke (1895, p. 11).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding——*typica.*
Spike wide, dense, the edges parallel, awns not widely spreading.
latispicatum Körnicke (as var., 1895, p. 11).
Spikes wide, very dense, awns widely spreading.
furcatozeocriton K. H. in Beaven (as var., 1902, p. 578).

19. *Hordeum distichon angustispicatum*—Continued.
Outer glumes narrow—Continued.
Kernels purple.
Spike narrow, lax, nodding.
koernickei K. H. in Beaven (as var., 1902, p. 579).
20. *Hordeum distichon rimpaui* Wittm. (Körnicke, 1895, p. 11).
Outer glumes narrow.
Spike narrow, lax, nodding——*typica.*
21. *Hordeum distichon nudum* Linnæus (1753, p. 85).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding——*typica.*
Spike wide, dense, the edges parallel; awns not widely spreading——*neogenes* Körnicke (as var., 1895, p. 10).
Spike wide, very dense, awns widely spreading.
gymnocrithum Körnicke (as var., 1895, p. 10).
Awns wanting——*duploalbum* Körnicke (as var., 1895, p. 8).
Kernels bluish.
Awns rough.
Spike narrow, lax, nodding.
rossii Körnicke (as var., 1895, p. 10).
Kernels purple.
Awns rough.
Spike narrow, lax, nodding.
ianthinum Körnicke (as var., 1895, p. 10).
Outer glumes wide.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
nudidubium Körnicke (as var., 1908, p. 431).
22. *Hordeum distichon nigrinudum* var. novo. This form was isolated in 1909 from an importation of Abyssinian barleys. Two naked seeds were found, which were so black that they appeared to have been charred. They proved viable, however, and have since produced coal-black seeds. In other respects the variety corresponds to *nudum.*
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding——*typica.*
Awns wanting——*duploatrum* Körnicke (as var., 1895, p. 8).
23. *Hordeum distichon laxum* Körnicke (1895, p. 7).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding——*typica.*
Spike wide, dense, erect——*densum* Körnicke (as var., 1895, p. 11).
24. *Hordeum distichon nigrilaxum* var. novo. This variety was produced from a cross of *horsfordianum* and *nigrinudum.* It is a 2-rowed, hooded barley of the species *distichon,* with naked black seeds, outer glumes narrow, spike narrow, lax, nodding.
25. *Hordeum deficiens deficiens* Steudel (1854, p. 351).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding——*typica.*

25. *Hordeum deficiens deficiens*—Continued.
Outer glumes wide.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
rehmii Körnicke (as var., 1895, p. 10).
Spike wide, dense, erect—*abyssinicum* Seringe (as var., 1842, p. 194; modified, Körnicke, 1882, p. 202).
Awns wanting—*subinerme* Körnicke (as var., 1895, p. 8).
Kernels bluish.
Awns rough.
Spike narrow, lax, nodding.
pseudoabyssinicum Körnicke (as var., 1908, p. 432).
26. *Hordeum deficiens steudelii* Körnicke (1882, p. 206).
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding—*typica.*
Awns smooth.
Spike narrow, lax, nodding.
subglabrum K. H. in Beaven (as var., 1902, p. 579).
Awns wanting—*subdecussatum* Körnicke (as var., 1895, p. 8).
Outer glumes wide.
Awns rough.
Spike narrow, lax, nodding.
macrolepis A. Br., (as var., 1848, according to Körnicke, 1885, Bd. 1, p. 185).
Awns smooth.
Spike narrow, lax, nodding.
leiomacrolepis Regel (as var., 1908, p. 78).
27. *Hordeum deficiens tricolor* Körnicke (1895, p. 11.)
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding—*typica.*
28. *Hordeum deficiens tridax* Körnicke (1895, p. 11).
Outer glumes narrow.
Spike narrow, lax, nodding—*typica.*
29. *Hordeum deficiens nudideficiens* Körnicke (1895, p. 11).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding—*typica.*
Awns wanting—*subduplialbum* Körnicke (as var., 1908, p. 434).
Kernels purple.
Awns rough.
Spike narrow, lax, nodding.
viviscens K. H. in Beaven (as var., 1902, p. 579).
30. *Hordeum deficiens decorticatum* Körnicke (1895, p. 11).
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding—*typica.*
Awns wanting—*subdupliatrum* Körnicke (as var., 1908, p. 434).

31. *Hordeum deficiens sublaxum* Körnicke (1908, p. 433).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding ..... *typica.*
32. *Hordeum deficiens gymnospermum* Körnicke (1895, p. 11).
Outer glumes narrow.
Spike narrow, lax, nodding ..... *typica.*

REJECTED SPECIES, SUBSPECIES, AND VARIETIES.

In the analysis of the relative value of the variable characters of barley, a number of variations were regarded as of too minor a nature to be used even in the description of named subvarieties. These included the elevation of the hood on a short awn, awns produced on the hood itself, malformed awns, short awns, the nature of the hairs on the rachilla, the toothing of the nerves of the lemma, and the widening of only the two outermost glumes at a node. Varieties established upon these characters are not recognized in the key. Inasmuch as the names often appear in papers on barley, a statement of the nature of the variation is necessary for reference use. For this reason an alphabetical list of discarded species and varieties has been prepared. A few groups founded on other bases have been included. The most important of these is probably that of compound spikes. The inclusion of compound spikes as a recognized character would simply double the number of varieties. In barley, proliferation of spikes is common, but in most strains it is not inherited. In others, while the tendency is transmitted, it is inherited imperfectly. Even if it were perfectly heritable its use would offer little of advantage. The list also contains various synonyms which have been published from time to time. In a few instances names occur both in the key and in the list of rejected forms. In these cases the names have been used in two or more ways and in the misapplied use appear here. Where the form is compared with one in the key, it bears the key number of the recognized variety.

ALPHABETICAL LIST OF REJECTED SPECIES, SUBSPECIES, AND VARIETIES.

abyssinicum Seringe (1842, p. 194, as. var.), as originally described equal to the species *deficiens.*

aegiceras Royle (1839, p. 418), synonym for *H. v. trifurcatum* (7).

aethiopicum Alefeld (1866, p. 343), synonym for *H. distichon nigricans* (18).

albidum Körnicke (1873, p. 4), synonym for *H. v. pallidum* (1).

angustissimum Körnicke (1908, p. 432, as var.), synonym for *H. distichon laxum* (23).

atratum K. H. in Beaven (1902, p. 597, as var.), synonym for *H. deficiens steudelii* (26).

atterbergianum Regel (1908, p. 77, as var.), synonym for *H. deficiens steudelii subglabrum* (26).

atterbergii Körnicke (1895, p. 10, as var.), *H. distichon palmella nutans* (17), with lateral florets enlarged and pointed.

brachytherum Körnicke (1882, p. 164, as var.), short-awned form of *H. v. pallidum pyramidatum* (1).

brachyura Alefeld (1866, p. 340), very dense form of *H. v. pallidum pyramidatum* (1).

beijerinckii Körnicke (1908, p. 431, as var.), *H. distichon palmella macrolysis* (17), with only the two outermost glumes expanded.

coelestoides Seringe (1841, p. 358), synonym for *H. distichon nudum* (21).

commune Atterberg (1899, p. 7), used as a subspecies to designate all barleys with narrow glumes and awned central florets.

compactum Körnicke (1908, p. 424, as var.), synonym for *H. v. horsfordianum hexasticofurcatum* (3).

complanatum K. H. in Beaven (1902, p. 577, as var.), synonym for *H. i. subcornutum anomalum* (11).

compositum Körnicke (1882, p. 206, as var.), compound form of *H. distichon palmella nutans* (17).

crispicapillum Körnicke (1895, p. 10, as var.), compound form of *H. v. coeleste* (5).

crispum Körnicke (1895, p. 4, as var.), compound form of *H. v. pallidum* (1).

cucullatum Körnicke (1882, p. 179, as var.), a malformation of *H. v. horsfordianum* (3).

densum Seringe (1841, p. 345 and 357), used for subvarieties under both *hexastichon* and *distichon.*

densum Voss (1885, p. 280), used to include all dense, narrow-glumed, deficient barleys.

eingens K. H. in Beaven (1902, p. 579, as var.), synonym for *H. distichon rimpaui* (20).

erectonudum K. H. in Beaven (1902, p. 578, as var.), synonym for *H. distichon nudum neogenes* (21).

falsum Atterberg (1899, p. 11), used to designate all varieties with horseshoe-shaped depression at base of grain.

flaccidum Voss (1885, p. 279, as var.), included lax forms of *H. v. coeleste* (5).

furcatum Atterberg (1899, p. 7), used as subspecies, including all hooded forms with linear outer glumes.

genuinum Alefeld (1866, p. 340), synonym for *H. vulgare*, used as *H. v. genuinum.*

genuinum Eriksson (1899, p. 2), a lax subdivision of *H. distichon palmella erectum* (17).

gracilius Körnicke (1882, p. 167, as var.), synonym for *H. v. nigrum schimperianum* (2).

heterolepis Körnicke (1882, p. 202, as var.), *H. distichon palmella macrolysis* (17), with only the two outermost glumes expanded.

heuzei Körnicke (1882, p. 170, as var.), *H. v. pallidum* (1), with malformed awns approaching hoods.

hexastichum Linnæus (1753, p. 85, as sp.), all dense forms of *H. vulgare.*

hibernum Heuzé (1872, p. 454), winter forms of *H. v. pallidum pyramidatum.*

imberbe Lamarck and Candolle (1815, p. 93), a form of *H. distichon palmella erectum* (17) with deciduous awns.

inaequale Voss (1885, p. 278), group term to include all lax *vulgare*.

inerme Atterberg (1899, p. 7), used as subspecies including all awnless varieties.

krausianum Wittmack (1885, p. 1), compound form of *H. distichon palmella erectum* (17), with some naked grains.

laxifurcatum K. H. in Beaven (1902, p. 578, as var.), synonym for *H. v. atrum* (4).

laxum Seringe (1841, p. 344 and 356), used to designate lax varieties under both *hexastichon* and *distichon*.

laxum Voss (1885, p. 281), including all lax deficient barleys with narrow glumes.

macrolepis Atterberg (1899, p. 7), used as subspecies, including varieties with wide outer glumes on the central spikelet.

macroteron Alefeld (1866, p. 340), less dense forms of *H. v. pallidum pyramidatum* (1).

monstrosum K. H. in Beaven (1902, p. 579, as var.), synonym for *H. deficiens gymnospermum* (32).

muticum Hoffmann (1877, p. 272), probably deciduous *H. distichon palmella* (17).

muticum Atterberg (1899, p. 8), as subspecies, including all varieties with large flowering glumes in lateral spikelets, whether fertile or infertile.

nigrescens Körnicke (1882, p. 195, as var.), a brown form of *H. distichon nigricans* (18).

nudiramosum K. H. in Beaven (1902, p. 578, as var.), compound form of *H. v. coeleste* (5).

parvihamatum K. H. in Beaven (1902, p. 579, as var.), short-awned form of *H. distichon angustispicatum* (19).

patens Eriksson (1889, p. 2), dense subdivision of *H. distichon palmella erectum* (17).

platylepis Voss (1885, p. 281), included all dense, wide-glumed *deficiens* barleys.

polystichon Haller (1776, p. 5), synonym for *tetrastichum* Körnicke, all lax *vulgare*.

polystichon Döll (1857, p. 119), all 6-rowed barleys.

pseudotrifurcatum Langsdorff (1860, p. 9), a form of *H. v. trifurcatum* (7) carrying a short awn.

ramosum Seringe (1841, p. 358), a compound *distichon*.

ramosum Hochstetter (1848, p. 147), a compound form of *H. deficiens* (25).

ramulosum K. H. in Beaven (1902, p. 579, as var.), a compound form of *H. distichon nudum* (21).

recens Körnicke (1882, p. 167, as var.), only two outermost glumes expanded, otherwise as *H. v. pallidum eurylepis* (1).

rectum Voss (1885, p. 278), dense forms of *H. v. coeleste* (5).

rostratum Atterberg (1899, p. 9), as *muticum*, except that the awnless spikelets of the former bear hairlike awns.

sativum Jessen (1855), used as a single species to include all cultivated barleys.

schweinfurthii Körnicke (1908, p. 420, as var.), synonym for *H. distichon nigricans* (18).

serratum K. H. in Beaven (1902, p. 579, as var.), synonym for *H. deficiens sublaxum* (31).

SPIKES OF FOUR FORMS OF BARLEY, SHOWING SEVERAL COMMON CHARACTERS.

A, *Hordeum vulgare trifurcatum*; *B*, *Hordeum vulgare coeleste violaceum*; *C*, *Hordeum intermedium haxtoni tonsum*; *D*, *Hordeum vulgare pallidum curvlepis*. Of these forms, *A* is hooded, *B* and *D* awned, and *C* awnless; *A* and *B* are naked, *C* and *D* hulled; *A*, *B*, and *C* have narrow outer glumes, and *D* wide outer glumes.

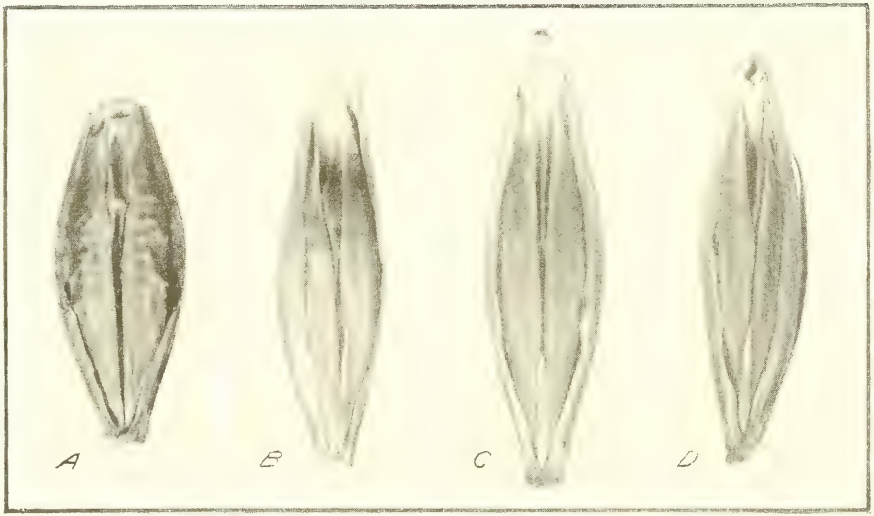


FIG. 1.—KERNELS OF 2-ROWED (A) AND 6-ROWED (B, C, AND D) BARLEYS.

The lateral kernels (*B* and *D*) of the 6-rowed barleys are twisted.

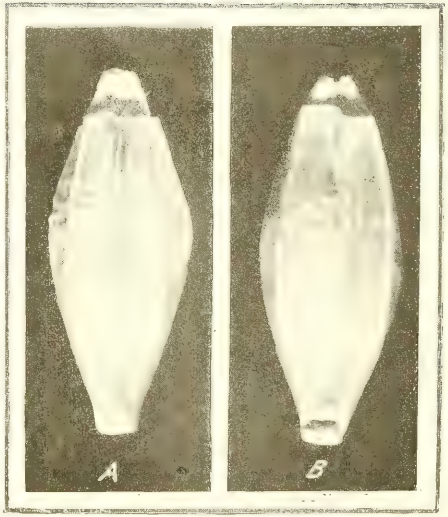


FIG. 2.—KERNELS OF LAX AND DENSE BARLEYS.

A shows the horseshoe-shaped depression at the base of the lax varieties and *B* the transverse crease usually occurring at the base of the erect varieties.

seringei Körnicke (1882, p. 206, as var.), a brown form of *H. deficiens steudelii* (26).

subatterbergii Körnicke (1908, p. 430, as var.), synonym for *H. i. nudihaxtoni nuditransiens* (13).

subcompositum Körnicke (1908, p. 434, as var.), a compound form of *H. distichon nudum* (21).

subhaxtoni Körnicke (1908, p. 429, as var.), an indefinite variation of *H. i. nudihaxtoni* (13).

spurium Atterberg (1899, p. 11), varieties with neither crease nor depression at base of grain.

tetrastichum Körnicke (1822, p. 125), all lax *vulgare.*

tortile Seringe (1841, p. 349), a 6-rowed barley with malformed awns approaching hoods.

tortile Robert (1832, according to Seringe, 1841, p. 349), probably as above.

tortilis Heuzé (1872, p. 457), probably as *tortile* Ser.

triangulare Körnicke (1908, p. 432, as var.), synonym for *H. distichon angustispicatum furcatozeocriton* (19).

utriculatum K. H. in Beaven (1902, p. 579, as var.), synonym for *H. distichon laxum* (23).

verum Atterberg (1899, p. 11), all varieties with transverse crease at base of grain.

violascens, K. H. in Beaven (1902, p. 578, as var.), synonym for *H. distichon palmella canescens* (17).

walpersii Körnicke (1882, p. 182, as var.), synonym for *H. v. coeleste* (5).

LINES FOR FURTHER STUDY.

The various characters upon which varieties have been founded have been discussed in connection with the keys and lists of varieties. Between most of the characters retained in the keys, the distinctions are quite sharp. There are a few, however, which are not exactly clear and which offer attractive fields for study.

The question of color is not on an entirely satisfactory basis. Colors are apparently the results of minor phases of metabolism, but have been utilized in taxonomic work because of the fact that they are conspicuous. Doubtless many more important features of metabolism are ignored in the grouping of varieties. Being a question of metabolism, and usually one of the altered metabolism of approaching maturity, it is questioned whether environment may or may not affect the production of pigment. This is particularly worthy of study in the blue and purple colors.

The variations of density are equally suggestive. There is no apparent reason why a strain of any given density can not exist, and in the grouping of varieties it would be worth while to know if there is even a narrow gap between the dense and lax forms. Possibly density, which has here been reduced to a subvarietal distinction, may have to be eliminated altogether. The separation of *deficiens* and *distichon* also presents possible difficulties. Hybrids of *deficiens*

and *distichon* do not fall clearly into the two groups of their parents. How much the heterozygous character is responsible for the confusion remains to be determined. How broad the interpretation of *intermedium* should be is also a matter of doubt. It may be that it should include forms in which the lateral florets are sterile but pointed. This would explain such forms as *atterbergii* Ecke., which most probably are genetically nearer *intermedium* than *distichon*, even though the pointing of the glume is a glume character and not one of fertility.

IDENTIFICATION OF THRASHED MATERIAL.

Of necessity the keys have been based on spike characters. Frequently, however, it is necessary to identify a barley from thrashed kernels alone. This is not always possible, but ordinarily the chance of error is negligible, owing to the fact that only one of the series of possibilities may with any likelihood occur under a given set of conditions. The observations to be made are taken up in the order in which they occur in the key.

By means of fertility only the first three species can be identified. *Deficiens* can not be separated from *distichon* with certainty on the basis of the grain alone. It may well be ignored, however, because varieties of *deficiens* are rare. They occur naturally only in Abyssinia and Asia Minor. In the United States they are found on few of our experimental stations and are almost unknown on farms. The first determination is usually as to whether the sample is 2 rowed or 6 rowed. This can be ascertained readily by the presence or absence of the lateral kernels in the sample. If it is 2 rowed, of course there will be no lateral kernels. As shown in Plate IV, figure 1, these lateral kernels can be identified by the twisted character. On the spike their bases lie almost in the same plane as that of the central kernel. Toward the tip, however, they gradually turn inward until the planes of the furrows approach a right angle. When the kernel is laid upon the dorsal side, this twist of the furrow is quite conspicuous. The species *intermedium* usually can be disregarded, because of the fact that it occurs very rarely. However, it is separated easily from *vulgare*. The lateral kernels are not only smaller than those of *vulgare*, but the tips are either rounded or (somewhat rarely) pointed, showing that neither awn nor hood had been present in the spike.

The adherence of the flowering glume is, of course, more apparent in the thrashed grain than in the spike itself, as the hulled and naked barleys are most easily identified by thrashing. The determination can be made, however, without injury to herbarium material, for the fine cross wrinkling never occurs on the lemmas of the naked forms, and the freedom of the glumes is itself apparent at the juncture of the lemma and palet.

The color of the grain is also as apparent in thrashed material as in the spike. The determination of the awned or hooded character is next to impossible if the sample has been thrashed clean. Ordinarily enough kernels still bear fragments of awns or hoods, as the case may be, to make this determination certain. If the barley has been clipped, the determination may be impossible. Naked varieties are more difficult to determine than hulled, and the identification must depend upon the fragments of awns and hoods which are likely to be present. Short, relatively thick kernels may be suspected of being the Nepal, which is the hooded, white, 6-rowed naked barley, but positive identification can not be made on this basis alone.

These characters carry the identification as far as the variety. If it is desired to determine the subvariety, it is necessary to establish the minor variations. This is not always possible, but fortunately the most common variations are the easier to determine. The more rare variations may be ignored with safety in 99 per cent of the samples. The varieties with wide outer glumes can not be separated from those with narrow glumes unless internodes from the rachis are present with the outer glumes attached. This is usually the case; but even if it were not, there is small chance of a wide-glumed variety being present.

Any difficulty encountered in the determination of color is usually confined to the separation of blue and white. As the blue color in hulled barleys is located in the aleurone layer, it is best to strip the lemmas from two or three grains, for weathering often so discolors them that it is impossible to see the blue color beneath. Purple color in these varieties is found in the glumes. In naked varieties the color is more readily seen, but is difficult of determination in immature specimens. Until well ripened, some white varieties have a greenish cast which might easily be confused with the blue. The blue and purple do not develop until near maturity. In blue barleys especially the color may be very pale. In well-matured specimens, however, there is little difficulty in making the determination.

The smoothness or roughness of the awns can be told if fragments of awns persist on any of the kernels. If the lateral nerves of the lemma are very scabrous, it may be taken for granted that the awns were rough. Smooth-awned varieties are so rare, however, that this may be disregarded.

Density usually can be determined from thrashed specimens, although not with absolute certainty. In extreme cases the identification is made easily. As shown in Plate IV, figure 2, there is a transverse crease at the base of the lemma in the dense varieties. In the lax ones there is a small horseshoe-shaped depression. The dense varieties of 6-rowed barley usually have the base of the lemma elongated, especially in the lateral florets. In most varieties of *inter-*

medium this extension is characteristic of the lateral florets of lax varieties as well. In barleys with awnless lateral kernels the observation should be made upon the central kernel. In the naked varieties density can not be determined with certainty from thrashed specimens.

VARIETIES GROWN IN FIELD CULTURE IN THE UNITED STATES.

Students and experimenters usually are interested in the variation that occurs in a crop as a whole, but there are also times when they are concerned only with local forms. For this reason it has been thought advisable to include a short list of the varieties and subvarieties which are grown in field culture in the United States. Although a very small percentage of the total number of forms is to be found, they are distributed through the groups in such a way as to be quite representative. The only forms which are entirely lacking are the deficient, wide-glumed, and smooth-awned varieties and subvarieties. The wide-glumed forms are not found in pure culture even at our experiment stations. Deficient barleys are grown at but few stations, and smooth-awned varieties at even a less number. The writer has a considerable number of smooth-awned selections in field tests in cooperation with the Minnesota Agricultural Experiment Station and elsewhere. *Hordeum vulgare pallidum* and *H. distichon palmella* include most of the agronomic varieties grown. The greater proportion of varieties in each case is found in the lax subdivisions. The following key includes a few well-known agronomic varieties in each of the more common subvarieties.

KEY TO COMMERCIAL VARIETIES.

Spikelets all fertile (6-rowed barleys).
  Lateral florets awned or hooded (sp. *vulgare*).
    Kernels hulled.
      Lemmas awned.
        Kernels white, blue, or purple (var. *pallidum*).
          Kernels white.
            Spike narrow, lax, nodding ---------- subvar. *typica*.
              Represented by the agricultural varieties Manchuria, Oderbrucker, Tennessee Winter, and white strains of Coast (Bay Brewing), etc.
            Spike wide, very dense, pyramidal, awns widely spreading ---------- subvar. *pyramidatum*.
              Represented by the agricultural varieties Winter Club (White Winter or Utah Winter), Tapps Winter, and Mariout.
          Kernels blue ---------- subvar. *coerulescens*.
            Represented by blue-gray strains of Coast and several pedigreed selections of Manchuria.
        Kernels black ---------- var. *nigrum*.
          Represented by the agricultural variety Gatami.

Spikelets all fertile (6-rowed barleys)—Continued.
Lateral florets awned or hooded (sp. *vulgare*)—Continued.
Kernels hulled—Continued.
Lemmas hooded——var. *horsfordianum*.
Represented by the agricultural variety Horsford Beardless (Success Beardless).
Kernels naked.
Lemmas awned.
Kernels white, blue, or purple (var. *coeleste*).
Kernels white——subvar. *typica*.
Represented by Jerusalem barley and other naked varieties, usually not named.
Kernels blue——subvar. *himalayense*.
Represented by the agricultural variety Himalaya Hull-less (Guy Mayle).
Kernels purple——subvar. *violaceum*.
Represented by the agricultural variety Black Hull-less.
Lemmas hooded——var. *trifurcatum*.
Represented by the agricultural variety Nepal (White Hull-less).
Lateral florets rounded or pointed, neither awned nor hooded (sp. *intermedium*).
Kernels hulled.
Lemma of central floret awned or awnless (var. *haxtoni*).
Lemma of central floret awnless——subvar. *tonsum*.
Represented by the agricultural varieties Arlington Awnless, Famesh, and in the dense form by Nakano Wase.
Central spikelets only fertile, lateral sterile or wanting (2-rowed barley).
Lateral florets present (sp. *distichon*).
Kernels hulled.
Lemmas awned.
Kernels white, blue, or purple (var. *palmella*).
Kernels white.
Spike narrow, lax, nodding——subvar. *nutans*.
Represented by the agricultural varieties Hanna, Hannchen, Moravian, Princess, Chevalier, etc.
Spike wide, dense, erect——subvar. *erectum*.
Represented by the agricultural varieties Svanhals, Primus, Goldthorpe, etc.
Kernels black——var. *nigricans*.
Represented by the agricultural varieties Black Smyrna and Black Arabian.
Kernels naked.
Lemmas awned.
Kernels white——var. *nudum*.
Represented by the agricultural variety McEwans, etc.

No attempt has been made in the above key to distinguish between the agronomic varieties within a subvariety. It is hoped to make

these separations in a later publication. In the varieties at present grown in America, separations are most difficult in the lax forms of the common 6-rowed barleys. In general, there are two groups, the Manchuria-Oderbrucker and the Coast. These groups are separated by the longer, heavier grain and the more tenacious awn of the latter. Within a group such as the Manchuria, identifications must be based on combinations of minor characters, such as the density of the spike, the nature of the hairs on the rachilla, the length of grain, and, if necessary, distinctive culm characters and the length of the growing season.

SUMMARY.

The variations that occur in barley are of importance to the student, agronomist, plant breeder, and pathologist. They offer a wide opportunity for selection, breeding, and studies of disease resistance. In barley the forms are unusually numerous and clearly defined. The number and character of the types existing are more concisely indicated by a classification of variations than in any other way.

The groups of barley have been arranged upon the basis of species, varieties, and subvarieties. Only major characters have been used in describing species and varieties; less important characters have been utilized in describing subvarieties. Under each subvariety there may be an unlimited number of agronomic varieties. Four species and 32 varieties are recognized.

All groups have been made to conform with previous usage as far as possible. One of the principal aims of the writer of this bulletin has been to state clearly the form or group intended to be described by each published name. Except for their historical significance, the subvarieties would not have been continued, and no forms have been added to them.

Four varieties have been added.

Lists of rejected terms and varieties are included.

The keys can be adapted to the identification of thrashed grain by a number of characters. In the common agronomic varieties the chance of error in the identification of thrashed grain is slight.

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UNITED STATES DEPARTMENT OF AGRICULTURE

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WM. A. TAYLOR, Chief

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CITRUS-FRUIT IMPROVEMENT: A STUDY OF BUD VARIATION IN THE WASHINGTON NAVEL ORANGE

By A. D. Shamel, *Physiologist in Charge*, L. B. Scott, *Pomologist*, and C. S. Pomeroy, *Assistant Pomologist, Fruit-Improvement Investigations, Office of Horticultural and Pomological Investigations.*

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INTRODUCTION.

The Washington Navel orange is the most important citrus variety grown in California. The total orange crop of the State, based upon the shipments of a normal year, is about 39,500 carloads, of which approximately 27,000 cars are of the Washington Navel variety.[1] In the report of the general manager of the California Fruit Growers' Exchange for the year ended August 31, 1916, it is stated that a total of 37,229 cars of oranges and grapefruit was shipped from California during that period. The grapefruit crop amounted to about 300 cars. It is also stated in this report that the California Valencia orange crop of the year under discussion would amount to between 13,000 and 14,000 carloads. No mention is made of the size of the crops of the Mission Sweet Seedling, Mediterranean Sweet, St. Michaels, Bloods, and other varieties, which are now grown to only a very limited extent in California, probably not to exceed 1,500

[1] Wallschlaeger, F. O. The world's production and commerce in citrus fruits and their by-products. Citrus Prot. League, Cal., Bul. 11, p. 70. 1914.

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carloads annually. From these figures it can be seen that the Washington Navel orange crop for the year 1916 was probably between 21,500 and 22,500 carloads. In northern and central California, the Washington Navel variety is shipped largely during the months of November, December, and January, while in southern California the crop is mostly shipped from January to June, inclusive. Owing to large plantings of this variety in northern and central California which have not yet come into full bearing, it seems likely that its production in the State will be increased in the near future.

The Washington Navel orange besides contributing such an important part to the citrus industry of California is extensively cultivated in the region of its nativity, Bahia, Brazil, and is grown commercially in Australia, South Africa, Japan, and some other citrus-growing regions. This remarkable development has occurred well within the past century and most of it during the last 25 years.

HISTORY OF THE WASHINGTON NAVEL VARIETY.

The Washington Navel orange (*Citrus sinensis* (L.) Osbeck) originated at Bahia, Brazil, apparently as a bud variation from the Portuguese orange variety, laranja Selecta. This variety, commonly called the Selecta orange, probably introduced into Brazil by the early Portuguese explorers and settlers, is supposed to have come from India. In Brazil the Selecta orange produces fruits bearing seeds and is one of the important citrus varieties grown in the vicinity of Rio de Janeiro at the present time. The occurrence of navel fruit variations in many trees in these orchards is corroborative evidence of the origin of the navel variety as a bud variation from the laranja Selecta.

As nearly as can be ascertained, the navel orange variation was first propagated about 1820 at Bahia[1] by a Portuguese gardener, who is said to have been the first person in Brazil to propagate plants by budding. The superior value of the seedless navel oranges in comparison with the seed-bearing Selecta fruits was soon recognized by the Bahians, and at the present time the navel orange has almost entirely supplanted the parent variety in the orchards at Bahia. In 1914 about a thousand acres of navel-orange trees were being cultivated within the municipality of Bahia,[2] while only a few individual Selecta trees were to be found in that district.

In 1868 the late William Saunders, Horticulturist of the United States Department of Agriculture, learned through a correspondent then in Bahia, Brazil, that the oranges grown there were seedless

[1] Interview with Dr. V. A. Argollo Ferrão, agricultural inspector of the Eleventh District, Bahia, Brazil, November, 1913.

[2] Estimate of the Brazilian agricultural exploring expedition of the United States Department of Agriculture, 1913–14.

and of a superior character. Arrangements were made for the importation of several of the trees for trial in the United States. When inspected at Washington all the trees in this shipment were found to be dead. From a second shipment, made in 1870, twelve living trees were received. Buds from these trees were propagated in one of the department greenhouses on orange stocks grown for this purpose and were distributed to growers in Florida and California.

In the distribution of these young budded trees, two of them were sent to Mrs. L. C. Tibbets, at Riverside, Cal., and were received and planted by her in 1873. One of these trees, shown in Plate I, was transplanted in 1903 from the Tibbets homestead to its present location in the courtyard of the Glenwood Mission Inn at Riverside.

When the two trees sent to Mrs. Tibbets came into bearing, about 1875, their fruits attracted much attention and aroused deep interest among many California citrus growers and propagators. The fine quality of the fruits, the absence of seeds, the distinctive navel mark, and many other striking characteristics led California citrus growers and nurserymen to propagate the variety very extensively. The commercial success of the fruit in the markets confirmed the judgment of the early propagators and growers as to the value of the variety. The propagation and planting of the navel orange in California have been carried on extensively during recent years, until now it is by far the most widely grown citrus variety in the State.

During the early stages of the development of this variety in California the name Bahia was proposed for it by Mr. Saunders. Other names were used locally, such as the Riverside Navel orange in the Riverside district. Because the two navel orange trees originally sent to California had been received from Washington, D. C., the name Washington was used frequently at first to designate the variety. After the trees fruited, this name was changed to Washington Navel. Gradually other names were abandoned and this name has since been used universally by citrus growers and others interested in the citrus industry.

In the selection of performance-record plats for these investigations, every possible care was taken to determine that the trees in the plats were the direct descendants of the two Tibbets trees. There is every reasonable assurance that all of the navel-orange trees used in these investigations are descendants of those trees and for the most part but two or three bud generations removed from the parent trees.

VARIABILITY WITHIN THE VARIETY.

A study of individual trees in several Washington Navel orange orchards in southern California begun by the senior writer in 1909 revealed the presence of several strains of trees and fruits showing

marked and important characteristic differences. The term "strain" as here used designates a group of individuals of a horticultural variety differing from all other individuals of the variety in one or more constant and recognizable characteristics and capable of perpetuation through vegetative propagation.

One of the theories most frequently advanced to account for the tree and fruit variations observed in the orchards was the possibility that the roots of such trees, or some of them, might be in so-called "soil pockets," or be influenced by other local soil conditions. The orchards in which the investigational performance record plats are located are situated on narrow mesas between low hills and a deep arroyo. The soil of these mesas is decomposed granite which has been washed down from the hills. A great number of soil analyses were made of samples secured within the areas covered by the root systems of trees of all the strains under observation, and such areas were found to be very uniform in character and composition.

The influence of the stocks upon the scions was suggested as another possible cause of the frequent variability observed, but this idea was proved to be erroneous by the discovery of numerous cases where some of the most distinct strains were found in the same tree grown from a single bud and therefore upon the same individual stock. Later it was discovered that in the case of these diverse bud variations occurring in the same tree grown from a single bud, it was possible to isolate each of the important strains through bud selection in propagation, proving that the differences observed were true cases of bud variation.

This variability of the trees and fruits of the Washington Navel orange is of fundamental significance from the standpoint of the fruit grower and in any study of the conservation and the stabilization of the variety as a whole. In the product of some groves, many oranges are found to be so poor as to be wholly unfit for the market. This condition frequently has been due to the presence of trees of inferior strains in the groves. These inferior trees reduce the returns from the grove in some cases to a point where from this cause alone it is maintained at a loss. Many of the existing trees of the variable strains show unusually strong vegetative growth but a low production of fruit, which is of inferior commercial value. The poor commercial quality of this fruit is due in part to the following causes: Irregular and peculiar shapes not adapted to a proper arrangement in the ordinary commercial packages; undesirable and unattractive color; rough, ridged, corrugated, or ugly and uneven surfaces of the rinds; very thick peel; a large amount of coarse rag; a small amount of juice or juice of a sour and bitter flavor; or other fundamental inferior fruit characteristics. Trees of some of the strains were found to bear extremely large fruits, and in other instances very small fruits,

both conditions being usually undesirable and unprofitable from the grower's standpoint. Considerable differences in the time of ripening of the fruits borne by the trees of some of the diverse strains in the same orchard were observed. This condition is objectionable in commercial orange growing, from the fact that frequently the differences in the ripeness of the fruits are not readily noticed by the pickers or packers.

On account of the presence of trees of inferior strains in the orchards, it frequently happens that fruit from them is shipped together with fruits of superior quality borne by trees of the best strain. Sooner or later the results of this condition are felt by the grower, and his fruit is sold with difficulty and at a low price. In order to maintain the reputation of a brand the grower must furnish regular and uniform supplies of good fruit to the consumer. In most cases in California brands are made up of the consolidated crops from many orchards. In order to standardize as much as possible the pack under such brands, it is necessary to use extreme care in assorting the oranges from the several groves from which the fruit is produced. From the standpoint of community endeavor this condition offers an additional reason for standardizing the fruit so far as practicable by the standardization of the trees in the groves through bud selection. The growing of inferior strains and the shipment of the fruits of these strains will sooner or later result in a loss of the reputation and prestige held by this variety.

The success of the Washington Navel orange is the foundation upon which the citrus industry of California has been developed. The importance of conserving the variety and maintaining it, now that its reputation has become established, must therefore be apparent to every thinking person.

OCCURRENCE AND FREQUENCY OF BUD VARIATIONS.

The total number of strains existing in the Washington Navel orange variety is unknown. Constant additions to the list are being made as knowledge of the variety grows and the extent of the investigations widens so as to include observations in a larger number of orchards and with a greater number of trees.

Thirteen important strains have been found in the investigational performance-record plats. Many other less marked departures from the Washington strain have been found from time to time, but are, so far as is now known, of little significance or importance in the consideration of methods for the stabilization of the variety by means of bud selection. These infrequent and less important variations therefore have not been included in the list of strains; but with a wider knowledge of these variations gained from actual experience

it is possible that some of them may be found to be more important than they are thought to be at the present time.

The great amount of variability within the Washington Navel orange variety has been thought by some to be coordinate with the abnormal conditions of its flowers and fruits. Subsequent investigations of varieties of citrus fruits other than the Washington Navel orange have proved that all citrus varieties thus far studied are subject to the variability arising from bud variations in about the same degree as is the navel orange.

Naturally many differences in fruits and trees are the direct result of the effect of environmental conditions. These seasonal fluctuations probably are of no importance from the standpoint of heredity and the stabilization of the variety, as apparently they are not transmitted by budding. Performance records showing these differences are, however, important from the standpoint of an investigation of cultural practices, in that they offer direct and valuable evidences of the effect of cultural treatment or other environmental factors upon tree behavior. These investigations have shown clearly that in cultural experiments, such as those in fertilization, irrigation, or other soil treatments, and in pruning or other methods of tree care, the effects of these treatments can well be measured by means of individual-tree records both before and during the experimental period. Individual-tree performance records afford exact data from which to draw conclusions as to the results of such experimental work.

The extent of the occurrence of diverse strains of the Washington Navel variety in established bearing orchards was found in subsequent investigations to be much greater than was apparent in the preliminary study of this subject. The lowest percentage of off-type trees, i. e., marked variations from the best or Washington strain, found in commercial orchards, has been about 10 per cent, and the highest about 75 per cent, of the total number of trees in the orchard. These figures do not refer to the many variations in fruits observed in the trees of the Washington or best strain, many of which are probably different enough from the Washington fruits to be classed as true strains, but owing to our incomplete knowledge of the subject they are of necessity for the present included with the Washington strain fruits.

The name Washington has been adopted for the typical strain of the variety because it represents that type of tree and fruits which was originally intended for propagation by the growers. It is the strain upon which has been founded the reputation of the variety and which under present conditions is the most desirable from commercial and other standpoints for cultivation in California.

Tree-census observations in navel-orange orchards in California show a general average of about 25 per cent of trees of diverse strains, most of which are inferior to the Washington as regards both the amount and the commercial quality of the fruit. As a rule, the younger orchards show a larger proportion of trees bearing inferior fruits than the older orchards. This condition indicates that the prevailing methods used for the propagation of the Washington Navel orange variety are causing the deterioration or "running out" of the variety as a whole through the perpetuation of an increasingly large proportion of undesirables

OBJECTS OF THE INVESTIGATIONS.

The objects of these investigations are (1) to ascertain the variation which has taken place in the Washington Navel orange through bud variation; (2) to determine the extent to which undesirable variations have been propagated, as shown by the percentage of such undesirable trees existing in the present bearing groves; and (3) through improved methods of propagation to control the extent to which undesirable variations shall enter into the population of future commercial Washington Navel orange groves.

PLAN OF THE INVESTIGATIONS.

These investigations have been carried on by means of individual-tree performance records and observations.

The term "performance record" is used here to mean the record of the number and the commercial quality of fruits borne by individual trees during a period of years.

The term "performance-record plat," as used in connection with these investigations, means a group of trees grown under comparable conditions, selected for the purpose of determining the relative behavior of the trees by means of individual-tree records of production, observations, and descriptive notes and records.

The individual-tree performance records made during these investigations were secured by giving each tree a number, by marking the trees annually with cloth streamers to prevent their accidental picking by the regular ranch picking crew, by picking each tree separately and assorting its fruits according to grade and size, by weighing each lot of fruit of each size and grade, by counting the fruits of each lot, and by recording these data on forms arranged especially for this purpose. In preparation for the work of assorting the fruits the season of 1909 was largely spent in citrus packing houses studying the grading standards in use in such houses at that time. Preliminary to each season's work since then, similar studies have been made in order to true up and improve the judgment of the observer when securing the investigational performance records.

In order that the data might be secured from trees located in orchards where the conditions were suitable for carrying out this work, a careful study was made in 1909 of many orchards in those districts of California where Washington Navel oranges were most successfully grown. Some of the conditions considered most desirable in the location of the performance-record plats of navel-orange trees for use in these investigations were (1) the production of successful and profitable crops; (2) location on virgin land in order to eliminate any influence of previous cultural treatments; (3) the absence of any radical pruning or other tree treatments or cultural practices; (4) the absence or effective control of diseases or insect pests; (5) the location of plats on uniform soils where little or no fertilizer or manure had been used and where uniform irrigation and other cultural practices had been continuously followed during the entire history of the orchards; (6) a knowledge of the history of the buds used in the propagation of the orchards and the character or kind of stocks used; (7) protection from cold, high winds, or other climatic causes of tree injuries; (8) the prospect of a continuous ownership of the orchard for a series of years; and (9) as little as possible apparent variability of strain, so that the results obtained would be conservative and fairly representative of the behavior of the individual trees from the standpoint of the variety as a whole.

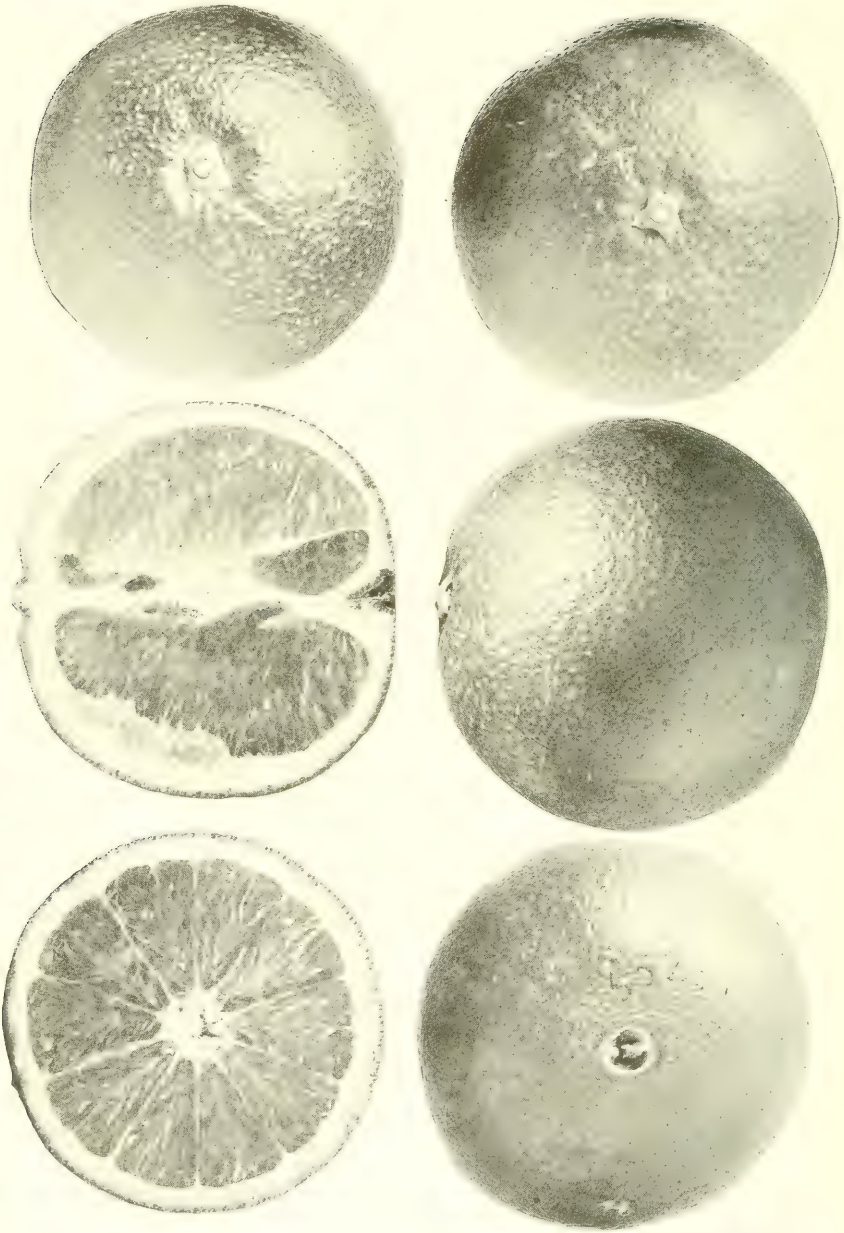
The preliminary survey of the Washington Navel orange districts made possible the selection of plats where these conditions were unusually uniform and particularly suitable for securing reliable and valuable data concerning individual-tree behavior. The ranches on which these plats were located are bounded on one or more sides by deep arroyos, thus providing good air drainage. In all cases these ranches are in the foothills and no other ranches are located above them, so that there was no possible influence on the performance-record trees from higher lying orchards or cultivated lands. All possible precautions were taken to provide against causes of individual-tree differences other than those resulting from individual-tree variability.

In the beginning it was considered most important to study the individual-tree variability within the Washington or best strain of the variety rather than to compare the behavior of the individual trees of the different strains. Later it was found to be equally important to consider the differences between strains arising from bud variations; therefore, plats selected subsequently were located mainly for the purpose of comparing the behavior of various strains of the variety. Inasmuch as the individual-tree performance-record work with the Washington Navel orange was, so far as known, the first investigation of this character with any citrus variety, the location of the plats was made without the knowledge which has since been

P930A–HP

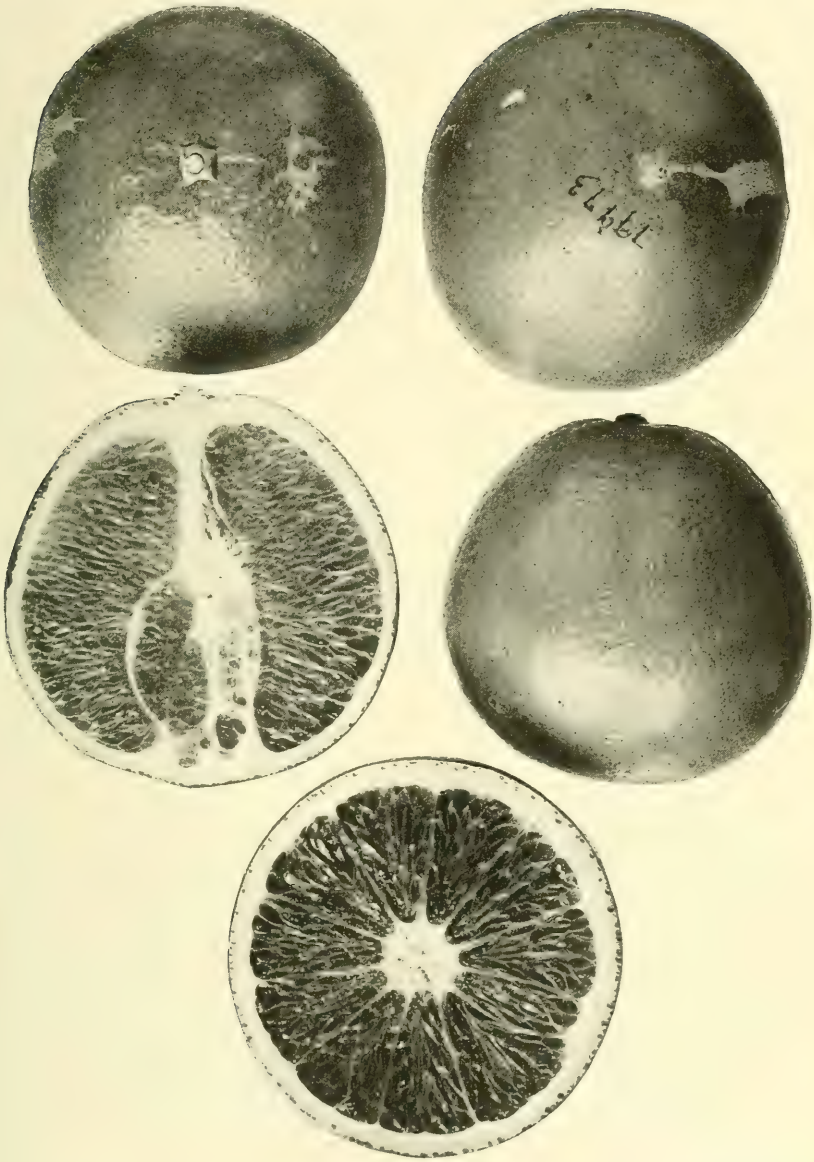
ONE OF THE TWO WASHINGTON NAVEL ORANGE TREES AT RIVERSIDE, CAL., GROWN FROM BUDS FROM TREES IMPORTED FROM BAHIA, BRAZIL, IN 1870.

From this tree and its companion the navel-orange industry of California has been developed within the past 45 years. Photographed in March, 1916.



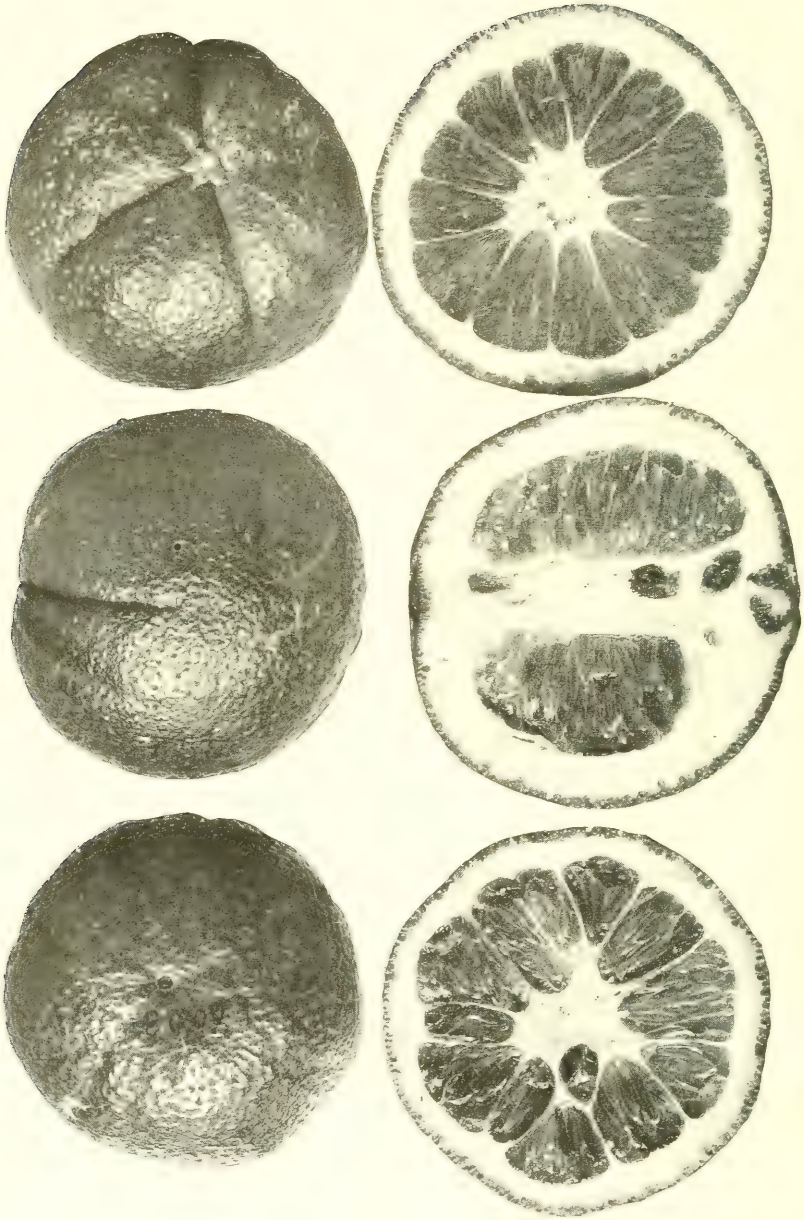
P104A–HP AND P105A–HP

TYPICAL FRUITS OF THE WASHINGTON STRAIN OF THE WASHINGTON NAVEL ORANGE.



P1030A—HP

TYPICAL FRUITS OF THE THOMSON STRAIN OF THE WASHINGTON NAVEL ORANGE.



P1069A–HP

TYPICAL WRINKLED FRUITS OF THE AUSTRALIAN STRAIN OF THE WASHINGTON NAVEL ORANGE.

available for consideration in the location of similar plats of other fruits.

The performance-record plats of the Washington Navel orange trees usually have included 100 or more trees. In some cases a smaller number, varying from 5 to 50 trees in a plat, has been used. All the plats on which detailed performance records have been obtained are situated in two adjoining orchards, and in their selection all known interfering environmental factors in individual-tree comparisons were avoided as far as possible. By the selection of these plats in uniform soil areas and in sections with the same elevation, like exposure, and comparable drainage conditions, it is believed that the results presented are less affected by fluctuations due to variations in soil fertility, moisture, or other environmental factors than would be the case were the records of all the trees in the orchards used for comparison. Records of a total of 743 Washington Navel orange trees are now being kept in this work.

METHODS OF KEEPING PERFORMANCE RECORDS.

In describing the methods developed in the course of these investigations for recording the behavior of individual trees in the performance-record plats, the methods of procedure are discussed in the order in which they are carried out. This arrangement will be of interest in planning similar work in other locations or with other fruits, in order that the performance-record work may be done in the most natural and logical manner.

TREE NUMBERS.

The individual trees in the performance-record plats were given numbers, so that the data secured from the study of each tree and its fruit could readily be kept separate during the entire period of observation. In the beginning, the trees were given consecutive numbers. These numbers were stamped in metal tags which were attached by wires to the limbs of the trees. This method of numbering soon became cumbersome and impracticable.

As a result of a careful study of this matter, a method of tree numbering was evolved which has proved to be satisfactory and has been adopted extensively in individual-tree performance-record and related work. By this method each tree is given a number consisting of three parts: (1) The number of the block or division of the orchard; (2) the number of the row in the block; and (3) the position of the tree in the row, always counting from some fixed point, as, for instance, the irrigation head. A tree located in block 5, row 6, and the seventh tree in the row has the number 5–6–7. Where several different orchards are under observation, the tree number in the performance-record notes is preceded by the number or name of

the orchard or its abbreviation. This system can be adapted to the conditions in any orchard and to any method of orchard management. For instance, in one of the orchards where investigational performance-record plats are located it was found desirable by the owner to subdivide certain plats rather than to give each such subdivision a separate plat number. This explains the use of the numbers 7: 1, 7: 2, etc., as plat designations in tree numbers in some of the following tables.

In the case of bearing trees, this number can be painted on the tree trunk or on one of the main limbs, arranging the number in a vertical column in the form shown in figure 1. A common lettering brush and pure white-lead paint are best adapted for this purpose. Very young trees on which space is not available for painting the number may be numbered by stamping or painting the number on a metal or other tag and attaching it to the tree.

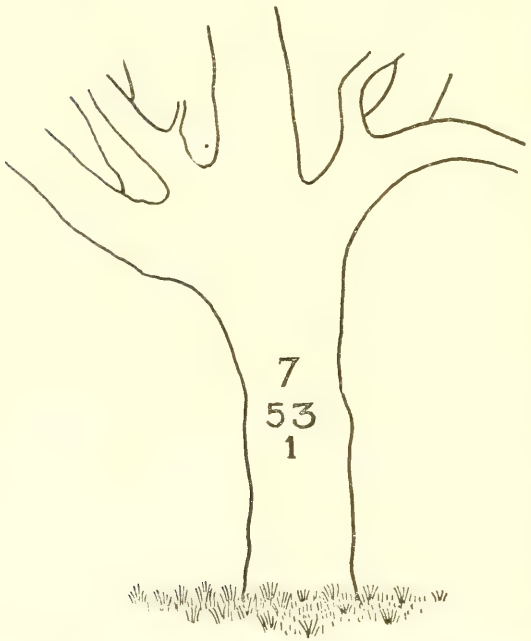


FIG. 1.—Arrangement of the individual tree number on the trunk of a tree.

The tree numbers are always placed in the same relative position on all of the trees in the orchard, for convenience in finding them. Large, distinct figures are made, so that they are easily legible.

TREE MARKERS.

Each individual tree in the performance-record plats is marked several weeks before picking with streamers of white cotton cloth (see figs. 3, 4, and 6), in order that the regular orchard crew will understand that they are not to be picked. Several streamers, about 1 inch wide and 3 feet long, are tied to projecting limbs on all sides of the trees as high as can be reached conveniently. These markers are renewed every season.

PICKING.

The picking of the performance-record trees is done by trained men, and, so far as possible, the same men are used year after year

in order to avoid possible errors which might be made by inexperienced pickers. Each tree is picked separately and its crop assembled at its base until needed for examination (see fig. 4).

ASSORTING.

All of the oranges picked during the day usually are examined that day, so as to avoid all possible injury to or changes in the fruit due to exposure. The fruits from each tree are assorted into three grades: An Orchard (or first) grade including all merchantable oranges which show no marked blemishes or other conditions detracting from their commercial value; a Standard (or second) grade,

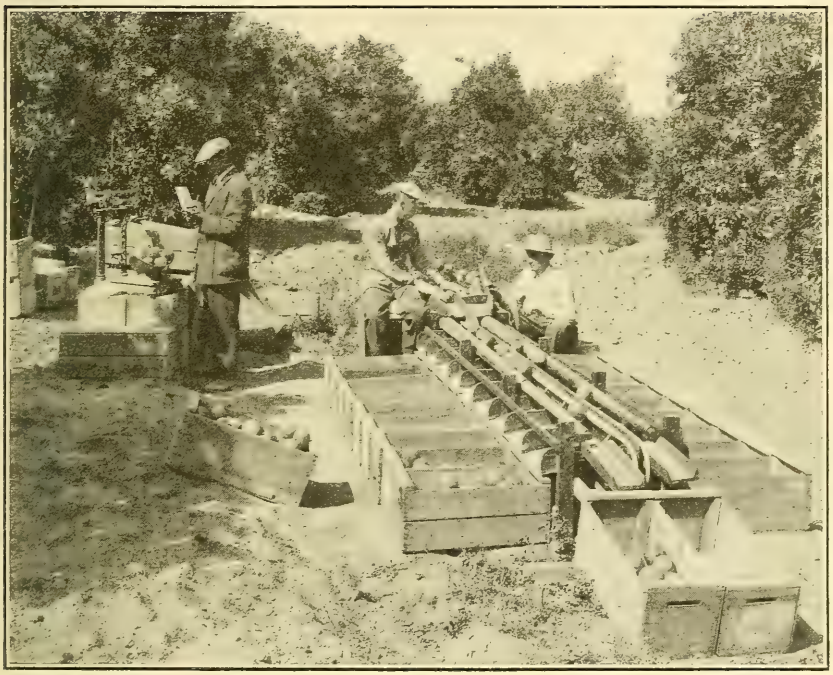


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FIG. 2.—Apparatus used in obtaining investigational performance-record data from individual orange trees.

including blemished and misshapen fruits and those of inferior appearance but of sufficient value for shipment; and Culls, or such fruits as are wholly unfit for the market. In addition to these grades a record is kept of all of the strikingly variable fruits, particularly those resembling the various strains of the Washington Navel orange and others showing marked characteristics apparently due to bud variability.

The orchard and standard grades are assorted into the 10 sizes most commonly used commercially. This work is done mechanically by means of a small specially constructed rope and roller sizing machine, as shown in figure 2. It is similar in operation to the regular packing-house machines used for this purpose, but adapted for orchard use.

The culls are not assorted in any way, but an explanation of the presence of any unusual number of them is noted. All of the fruits, including the drops on the ground under the trees, are secured by the pickers, those showing decay being kept in a separate box in order to avoid the spread of diseases to the sound fruits.

WEIGHING.

The fruits of each size in both the orchard and standard grades are weighed on ordinary small platform scales adapted for this purpose (fig. 2). Great care is used to secure accurate weights, inasmuch as under orchard conditions unusual precautions must be taken to avoid errors through the variable weights of fruit containers, frequent changes in the location of the scales, and other causes. The culls are weighed and counted collectively.

COUNTING.

After weighing, the fruits of each size in the orchard and standard grades are counted carefully and the numbers recorded in the proper places in the field performance-record forms. During the counting the fruits of variable strains and others of special interest are set aside for later classification and study.

RECORDING DATA.

The forms used in the orchard for recording the individual-tree performance-record data are shown in Table I. These forms are printed on both sides of sheets 6½ by 4 inches in size, which are bound 50 in a book, a size convenient for field use. As soon as possible these records are transferred to annual sheets (see first part of Tables VII to IX), on which the data are summarized to show the total crop of each tree for the year. These summaries are in turn transferred to period forms (see Tables VIII and XII), on which the records for six years can be assembled for comparison and study. These two last-mentioned forms are printed on sheets 8 by 10½ inches in size, arranged for binding in loose-leaf covers.

The value of all performance-record data depends upon the accuracy with which it is secured and recorded. Too much emphasis can not be placed on the necessity for the adoption of all possible safeguards to insure the reliability of the data. A regular method of procedure in weighing and counting the fruits and recording the data has been adopted and adhered to in all the investigational work. Freedom from interruption is of primary importance, because any distraction from this work is likely to cause errors. It is also desirable that as far as possible the same person should secure the records on all the trees in any given plat for the entire season, and preferably for the entire period of the investigations. As soon as the fruit is examined and the necessary records secured it is hauled

to the packing house, except such samples as may be needed for further study. In view of the fact that during the performance-record work each orange must be handled several times, the greatest possible care is used in picking and handling in order to avoid as far as possible all mechanical injuries.

Methods for securing commercial individual-tree performance records as a part of the regular fruit-picking operation are described and illustrated in United States Department of Agriculture Farmers' Bulletin No. 794, entitled "Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records."

TABLE I.—*Forms used in investigational work for individual Washington Navel orange-tree performance records, showing the data from tree No. 3–14–27, Vivienda ranch, for the year 1914.*

[Horticultural and Pomological Investigations, B. P. I. form 264–1. The weights are expressed in pounds and ounces.]

A.—Front of sheet, showing the form for recording the number and weight of the fruit of the different sizes.

Grove, *Vivienda*. Plat *3*. Row *14*. Tree *27*.
Variety, *Washington Navel*. Strain, *Washington*.

Orchard grade.			Standard grade.		
Size.	Weight.	Number.	Size.	Weight.	Number.
288	*1–10*	*8*	288	*1– 1*	*6*
250	*5– 6*	*19*	250	*0–15*	*3*
216	*19–14*	*59*	216	*2–10*	*7*
200	*51–15*	*133*	200	*2–12*	*7*
176	*126–10*	*277*	176	*6–12*	*16*
150	*125–12*	*238*	150	*4– 9*	*9*
126	*99– 6*	*167*	126	*4– 8*	*8*
112	*21–14*	*33*	112	*1– 4*	*2*
96	*8– 4*	*11*	96	*0– 0*	*0*
80	*0–13*	*1*	80	*0– 0*	*0*

Date, *February 24, 1914*. Number of boxes, *11½*. Culls, *38;* weight, *17–4*.

B.—Back of sheet, showing the form for recording the variable fruits found on the tree.

Sports.	
Australian	*1*
Wrinkled	
Flattened	
Corrugated	
Protruding	*3*
Yellow	
Ridged	*3*
Ribbed	
Creased	
Raised section	
Sunken section	
Raised and sunken	
Yellow section	
Golden nugget	
Abnormal shape	*1*
Split navel	*7*
Split side	*3*
Pear shape	
Elliptical	
Long	
Very smooth	
Coarse	
Striped	
Off bloom	

NOTE.—*Fine quality fruit.*

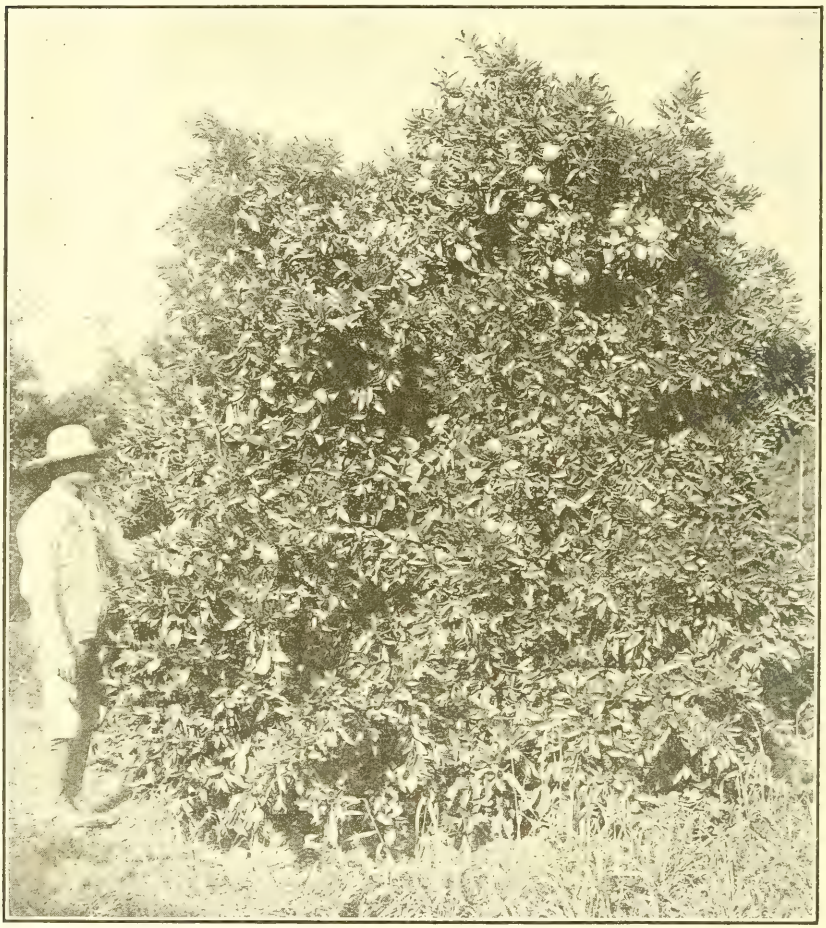
DESCRIPTIVE NOTES.

In addition to the performance-record notes, detailed descriptions are made of representative trees and fruits of the different strains and variations in the orchard. Specially prepared forms are used in securing these data, so that all the records obtained will be comparable and arranged in the same sequence for the purpose of intelligent study. These systematic notes are particularly valuable in interpreting the behavior of the individual trees and in obtaining information concerning the correlations of production and the physical characteristics of the individual trees and fruits.

DESCRIPTIONS OF SOME OF THE IMPORTANT STRAINS.

WASHINGTON STRAIN.

The trees of the Washington strain, illustrated in figures 3 and 4 before and after the crop was picked, are productive and tend to bear regular and successive crops of fruit. They have an open and somewhat drooping habit of growth and dense foliage with large



P731A-HP

FIG. 3.—A typical Washington strain orange tree of the Washington Navel variety located in one of the investigational performance-record plats. Note the white cloth streamers used to mark the tree. This tree after the crop was picked is shown in figure 4. The performance record of this tree for four seasons is given in rank 82 in Table IV.

dark-green leaves. The trees of this strain produce but few suckers, i. e., branches showing abnormally vigorous vegetative growth in contrast with the large amount of such growth produced by trees of some other strains of the Washington Navel orange. Fruit variations are less commonly found in the trees of this strain than in the

trees of the other strains of this variety (see fig. 14). So far as observed no flowers of this strain have been found in which the anthers develop pollen.

The fruits, illustrations of which are shown in Plate II, are obovoid and of medium to large size. The rind is of medium thickness

P 732A—H P

FIG. 4.—A typical Washington strain orange tree of the Washington Naval variety in the investigational performance-record plat with its crop picked and assembled and ready for inspection. This tree is shown before picking in figure 3. The performance record of this tree for four seasons is shown in rank 82 in Table IV.

and the texture is smooth and grained. The color of the fruit is bright orange; the rag is tender and of comparatively small amount; the juice is abundant and of superior quality, having a pleasing and sprightly subacid flavor. The fruits are seedless and the navel

usually is small, frequently rudimentary, with no development except in the rind.

The Washington is the most valuable of all the Washington Navel orange strains on account of the high productiveness of the trees and the superior commercial quality of the fruit. The commercial characteristics of the oranges of this strain are not equalled in value by those of any other navel orange grown in California at the present time.

THOMSON STRAIN.

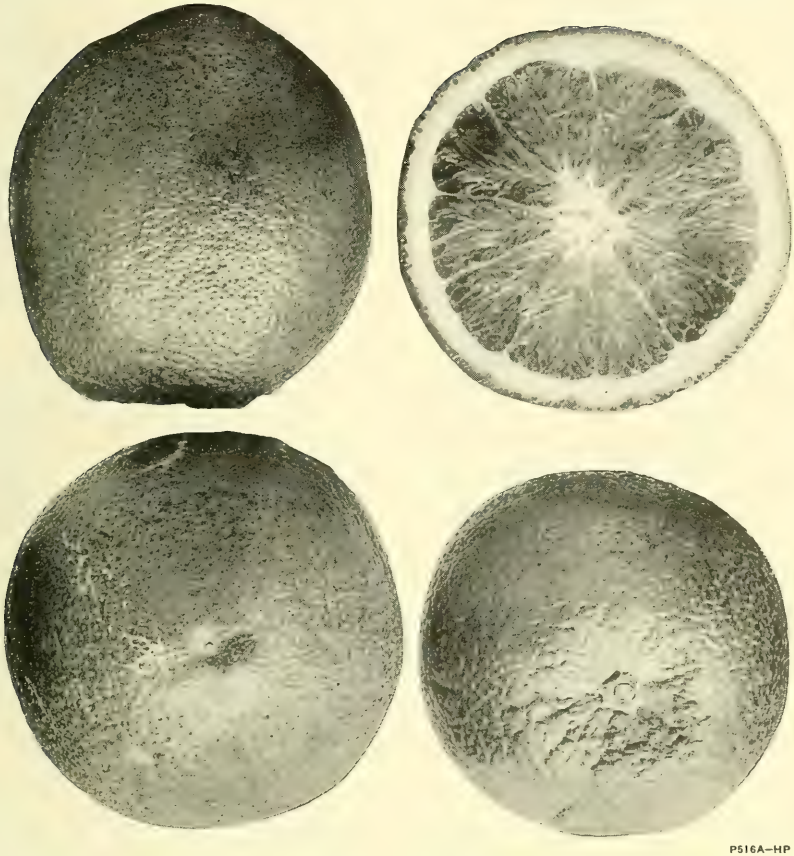
The Thomson strain, frequently called the Washington Improved or the Thomson Improved, has been extensively propagated commercially and is generally recognized in California as an established

P545A-H

FIG. 5.—A typical tree of the Australian strain of the Washington Navel orange (at the left) in comparison with a typical tree of the Washington strain (at the right).

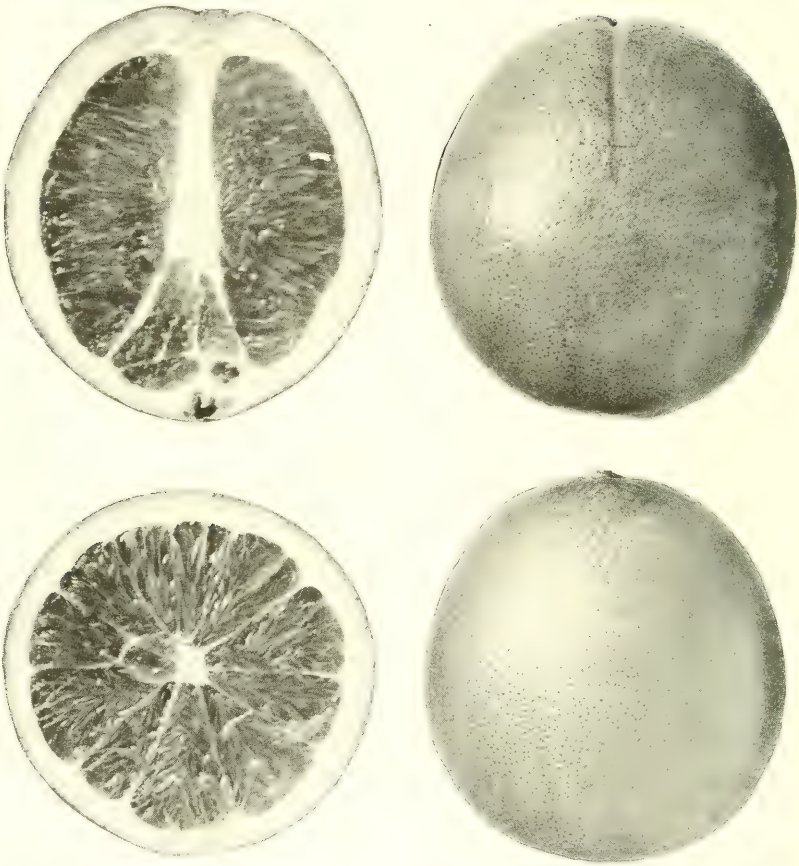
variety.[1] Trees, individual fruits, and limbs bearing several fruits of this strain frequently are found in orchards of trees of the Washington strain, showing that it is a common bud variation. The trees show an unusual degree of variability in the character of their fruits, one tree frequently bearing several distinct strains. The established orchards of this strain show tree and fruit variations to such an extent that this condition is recognized as distinctly detrimental to its commercial value. Most of the Thomson trees in the investigational performance-record plats have produced one or more fruits

[1] In the Yearbook of the U. S. Department of Agriculture for 1911, pp. 436–438, the history and a complete description of this strain are presented by Dr. Wm. A. Taylor. At the time of the preparation of this paper it was thought by most growers that the Thomson orange was an established variety of independent origin from the Washington Navel orange. These investigations have shown that it is but a strain of the Washington Navel orange.



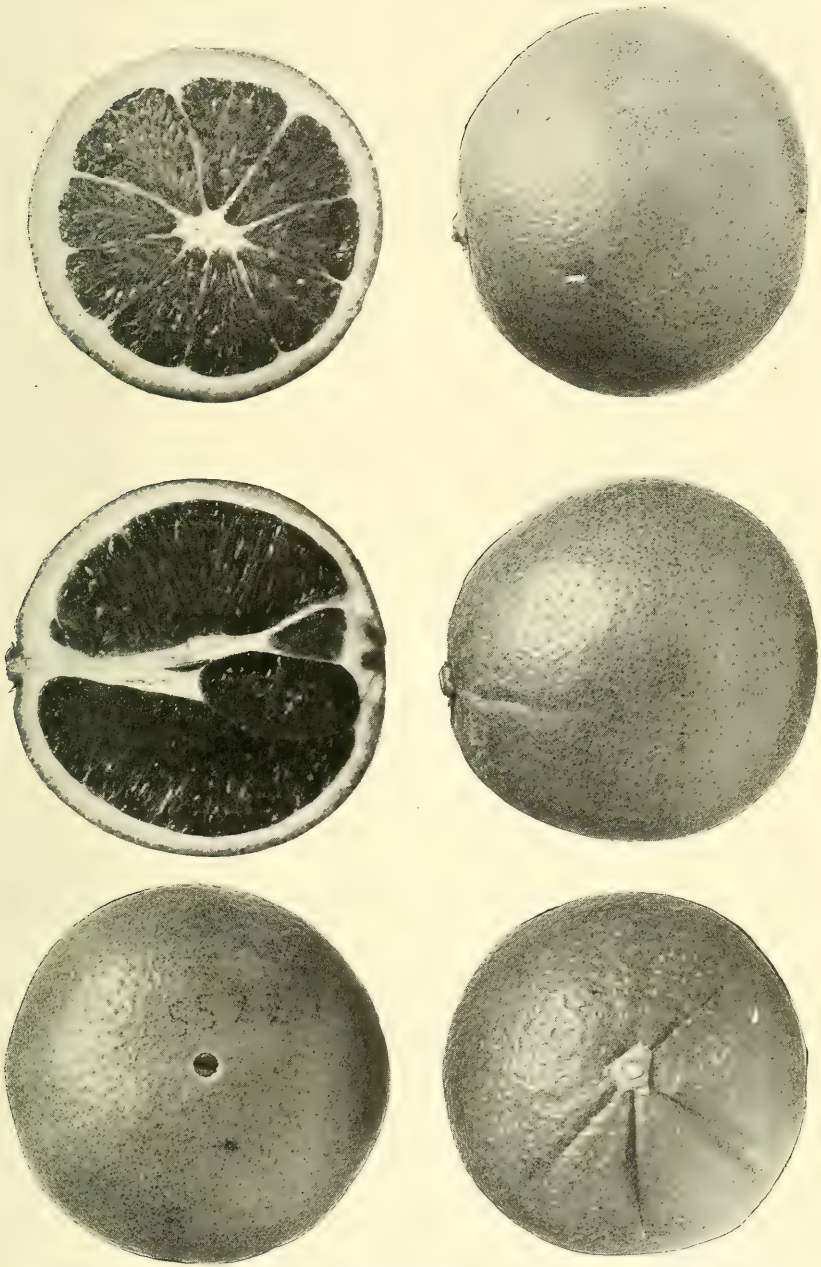
P516A–HP

TYPICAL COARSE FRUITS OF THE AUSTRALIAN STRAIN OF THE WASHINGTON NAVEL ORANGE.



P116A–HP

TYPICAL FRUITS OF THE GOLDEN NUGGET STRAIN OF THE WASHINGTON NAVEL ORANGE.

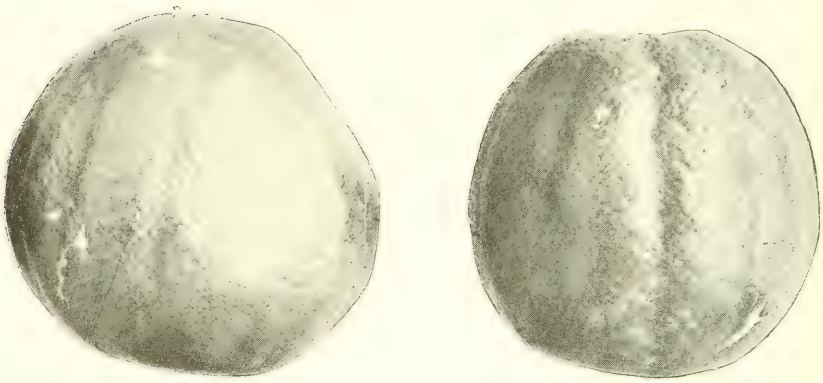


P100A–HP AND P101A–HP

TYPICAL FRUITS OF THE YELLOW STRAIN OF THE WASHINGTON NAVEL ORANGE.

P1058A–HP

FIG. 1.—STEM ENDS.



P1060A–HP

FIG. 2.—SIDES OF THE SAME FRUITS.

P1059A–HP

FIG. 3.—AXIAL SECTIONS OF THE SAME FRUITS.

TYPICAL FRUITS OF THE RIBBED STRAIN OF THE WASHINGTON NAVEL ORANGE.

of the Washington strain every season during the period of observation. From the standpoint of the study of the behavior of citrus-fruit variations, this strain is one of the most interesting of those under consideration.

The trees of the Thomson strain are heavy and regular bearers, have an open and drooping habit of growth, dense foliage, and large dark-green leaves. As a rule, the trees of this strain are not as vigorous growers as those of the Washington strain under similar conditions.

The fruits, illustrations of which are shown in Plate III, are similar in shape and size to those of the Washington strain. They differ from them mainly in having a very smooth rind of a bright reddish orange color. The rind of the Thomson fruits is thinner and the rag is more abundant and coarser than that of the fruits of the Washington strain. The smooth texture, bright reddish color, and handsome appearance of the fruits is of distinct value from the market standpoint. The juice usually is less acid than that of oranges of the Washington strain and is lacking somewhat in flavor. The undesirable characteristics of the rag and the inferior quality of the juice are detrimental to the reputation of the fruits of this strain. The fruits are seedless and the navels variable in size and arrangement, usually medium to small, occasionally rudimentary.

Among the interesting fruit variations observed in the Thomson trees are those having the Thomson rind characteristics and the Washington rag and juice qualities, a Thomson-Washington strain; and the reverse of this condition, a Washington-Thomson strain.

AUSTRALIAN STRAIN.

The name Australian seems to have been used frequently on account of the resemblance of the trees of this strain to those grown in California from certain Australian importations. It has gradually been adopted by citrus growers to indicate the rank-growing, unproductive Washington Navel trees which bear coarse, inferior fruits. As a matter of fact, the name is used frequently to include several distinctly inferior variations of the variety and it is here used in this collective sense.[1]

The trees, an illustration of which is shown in figure 5, are either regularly unproductive or produce crops at irregular intervals. The typical trees have a peculiar upright habit of growth and usually show more than ordinary vegetative vigor. Many trees of this strain produce a very large number of suckers, which until recently have been highly prized for bud wood for use in propagation. The foliage normally is sparse and the leaves are comparatively small, narrow,

[1] In Bulletin 1, Division of Pomology, U. S. Department of Agriculture, on p. 67, under the head of "Navel (Australian)," the following statement concerning the origin of this strain occurs: "Originally from Bahia, Brazil, by way of Australia and California. Tree shy bearer."

and sharply pointed. The trees usually can be picked out in established orchards by the fact that unless freshly pruned they stand several feet above neighboring trees of other strains. Efforts to induce fruitfulness in the trees of this strain by severe pruning or other similar tree treatments have been unsuccessful, the effect of pruning being to induce increased vegetative growth.

The fruits from trees of the Australian strain fall into three groups: Those resembling Washington fruits except as to size and quality; those having a flattened shape with a peculiar wrinkled or ribbed appearance about the stem end, as shown in Plate IV; and those of large size and globular shape, with a very coarse, rough texture of rind, which is frequently correlated with an unusually thick rind and inferior quality of juice, as shown by its low sugar content. Illustrations of this last group are shown in Plate V. The Australian fruits are usually yellowish orange in color and are inferior in commercial value to those of the Washington and Thomson strains. The rag generally is abundant and coarse. The juice usually is small in quantity, of poor flavor and inferior quality. The fruits normally are seedless and have large navels, which, in some cases, form large protuberances. These detract from the appearance and market value of the fruits and are likely to be injured in handling. Under the operation of a sugar and acid ratio standard in commercial picking, the fruits of the Australian strain usually do not come up to the maturity standard during the regular picking season and therefore must be left on the trees or discarded, making their production almost or wholly a total loss to the growers.

Several trees of the Australian strain in the performance-record plats have been top-worked by using bud wood from Washington trees. The buds of the Washington strain in the Australian trees have made very satisfactory growth and have produced Washington strain foliage and fruits. As a rule, it has required from three to five years to bring the rebudded Australian trees up to the normal production of neighboring Washington trees.

GOLDEN NUGGET STRAIN.

The Golden Nugget strain,[1] like the Thomson, has been propagated commercially in California and is accepted as a distinct variety by many nurserymen and growers, having been introduced by the San Dimas Nursery Co., of San Dimas, Cal.,[2] and by Mr. J. P. Engelhart, of Glendora, Cal.[3] Its commercial cultivation is limited, being confined for the most part to a few small experimental plantings. In most navel-orange groves trees of this strain are of frequent

[1] Sometimes called the Golden Buckeye.

[2] Nursery catalogue of the San Dimas Nursery Co., 1903–4. In this publication the Golden Buckeye and Golden Nugget navel oranges are listed separately.

[3] Personal interview with Mr. Engelhart, May 17, 1910.

occurrence. Some trees of the Washington, many of the Thomson, and a few of the other strains in the investigational performance-record plats have been found to bear individual fruits of this strain. Occasional limbs have been found in such trees producing typical Golden Nugget fruits consistently from year to year during the entire period of observation.

This strain, as in the case of the Australian, is really made up of several groups, differing in some minor respects but having certain general points of common resemblance. In the further study of this strain the characteristics of trees and fruits of these groups are being given careful consideration. In this discussion, however, the various groups constituting the strain will be treated collectively as belonging to the same strain, because at the present time the fruits of all are considered as belonging to one class from the commercial standpoint.

The trees of the Golden Nugget strain are, as a rule, less vigorous growers than Washington trees, the habit of growth is drooping, and the foliage dense. The leaves frequently are of lighter color than comparable ones of the Washington strain, and in many cases the trees are easily distinguished in the orchard by reason of the light-colored foliage and the characteristic dwarf and drooping habit of growth. In some instances the habit of growth, foliage, and other tree characteristics are almost indistinguishable from those of the Washington or Thomson strains. The fruits borne by such trees differ in some respects from those produced by the dwarf-growing Golden Nugget trees, but not enough to warrant a separate classification and description at this time.

The Golden Nugget fruits, illustrations of which are shown in Plate VI, usually are somewhat pyriform in shape and of medium to large sizes. The rind is thin and of smooth texture. The color of the fruit is light yellowish orange, the rag is coarse and abundant, and the juice is fairly abundant and frequently of distinctive quality. The fruit is seedless and has very small and usually only rudimentary navels in which the opening is nearly or entirely closed. The fruits have a peculiar and unmistakable appearance, due in part to the presence of comparatively few oil cells, the light yellowish color of the rind, and the pyriform shape of the oranges. In some cases the fruits bear narrow red stripes or characteristic red ridges or knoblike projections.

As a whole, this strain is not a valuable one for commercial planting, and the presence of such trees in established navel-orange orchards is detrimental to the commercial value of the crops produced by these orchards. At the same time the striking characteristics of the fruits of this strain and their frequent and easily recognized occurrence in trees of other strains make it important from the

standpoint of the study of the origin and behavior of Washington Navel orange strains arising from bud variations.

YELLOW WASHINGTON STRAIN.

The trees of the Yellow Washington strain usually are less productive than true Washington Navel trees. The habit of growth is somewhat erect and the foliage rather sparse. The leaves are likely to be small, slightly pointed, and light green in color.

The fruits, illustrations of which are shown in Plate VII, are similar in shape, size, and thickness and texture of rind to those of the Washington strain, but the color is markedly different, being a light yellow, which in some cases becomes orange yellow late in the season. The characteristics of the rag and juice are somewhat similar to those of the Washington strain, except that as a rule the fruits ripen a little earlier and the flesh is markedly lighter in color. The fruits are seedless and the navel is usually small to medium in size. In many cases the fruits bear characteristic small red stripes, or blotches, similar in appearance to those found on many Golden Nugget fruits. It is believed by some growers that this strain may prove to be of commercial value under certain soil and climatic conditions, and a few small orchards of these trees have been planted. The fruits occur as infrequent bud variations in some Washington strain trees in the performance-record plats.

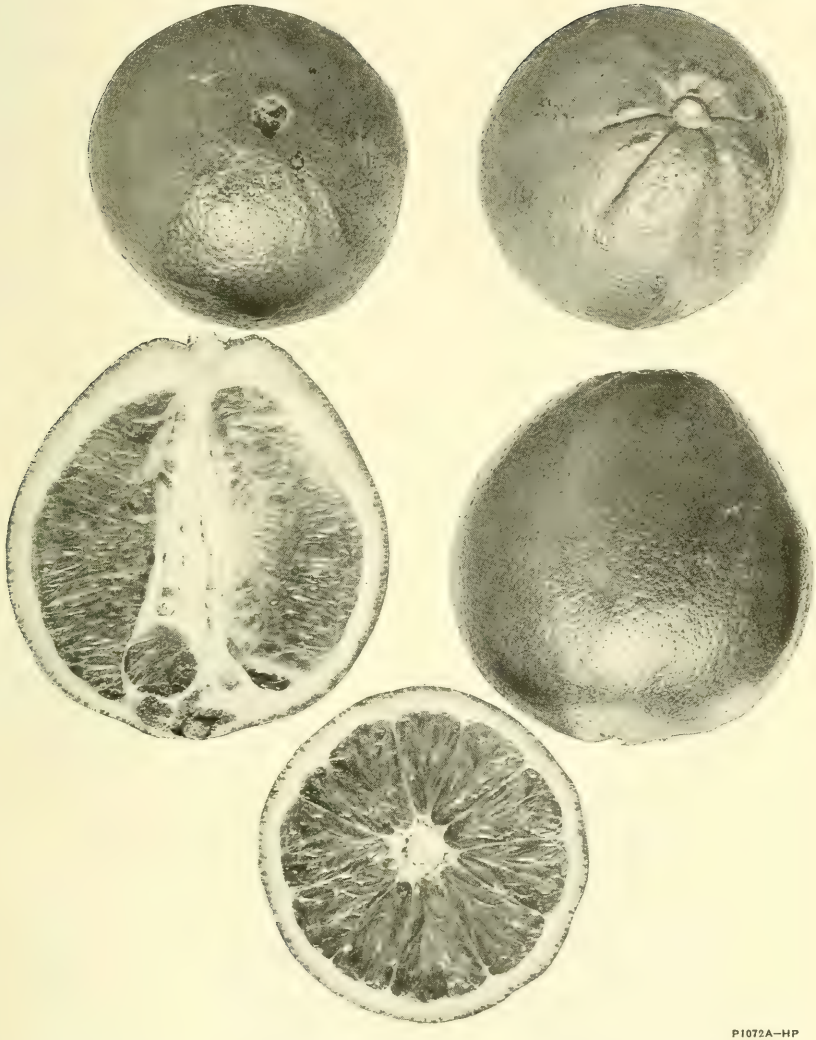
YELLOW THOMSON STRAIN.

The trees of the Yellow Thomson strain under observation are similar in production, habit of growth, and foliage characteristics to the Thomson trees.

The fruits resemble typical Thomson fruits with the exception of their color and some characteristics of minor importance. The color of the fruits of this strain is yellow to yellowish orange, and they frequently show small red markings. As a rule, the fruits seem to ripen somewhat earlier than those of the Thomson strain under comparable conditions. This strain holds about the same relation to the Thomson that the Yellow Washington holds to the true Washington strain. It is of little commercial value and is of interest mainly from the standpoint of the study of the variability existing in the Washington Navel variety. Individual fruit variations of this strain occur frequently in Thomson trees, and occasionally Yellow Thomson limb sports have been found.

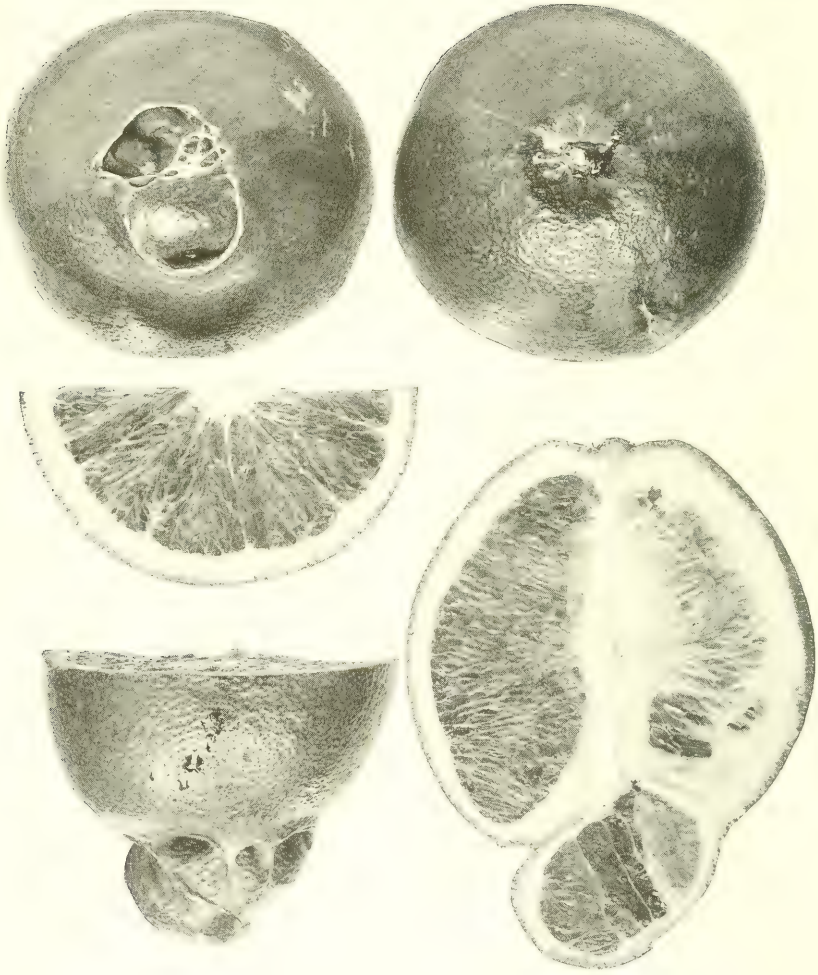
RIBBED STRAIN.

The habit of growth of the trees of the Ribbed strain resembles that of the Washington trees except that usually they are more finely branched. As a rule, they are not as productive as Washing-



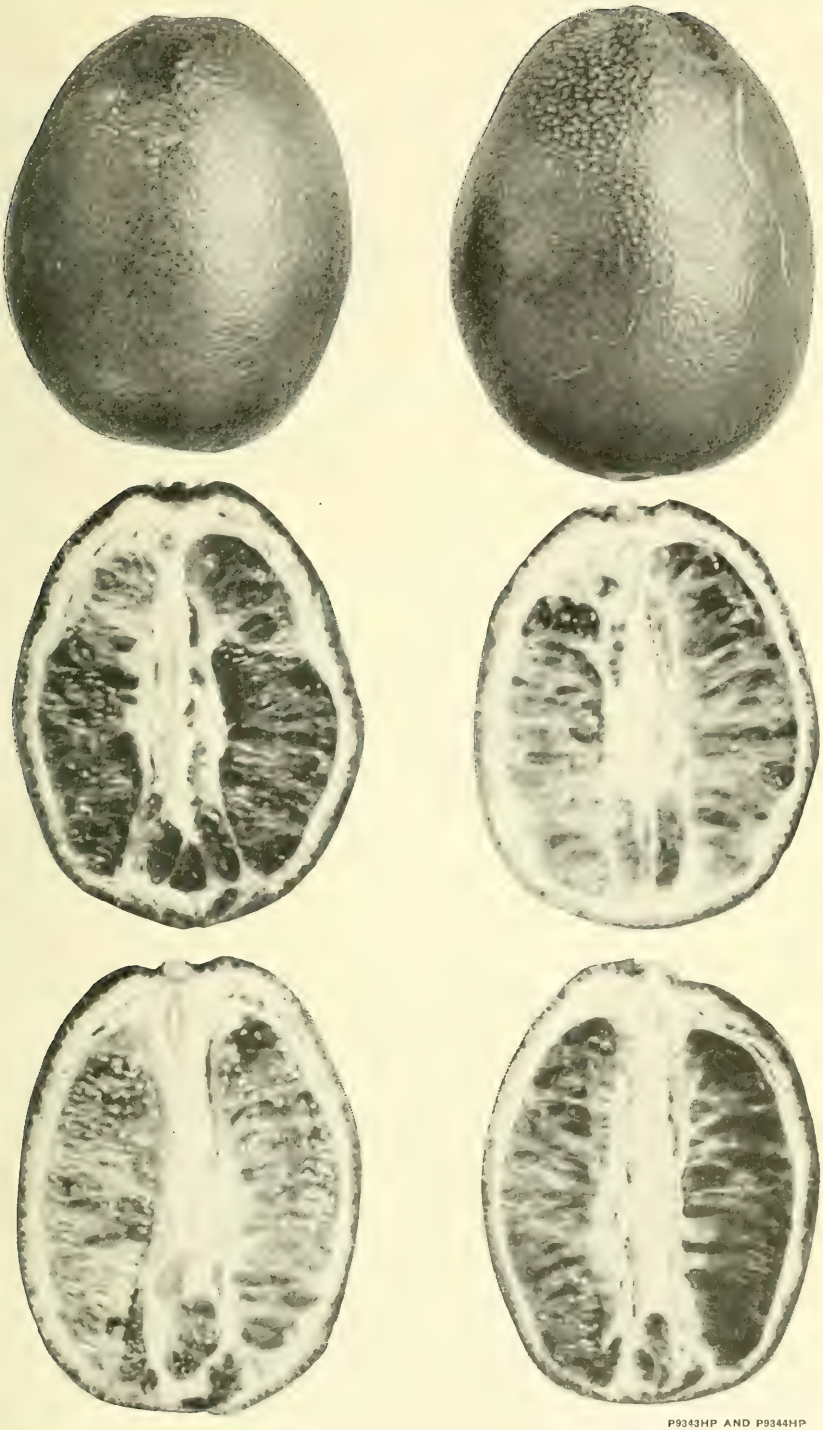
P1072A—HP

TYPICAL FRUITS OF THE PEAR-SHAPE STRAIN OF THE WASHINGTON NAVEL ORANGE.



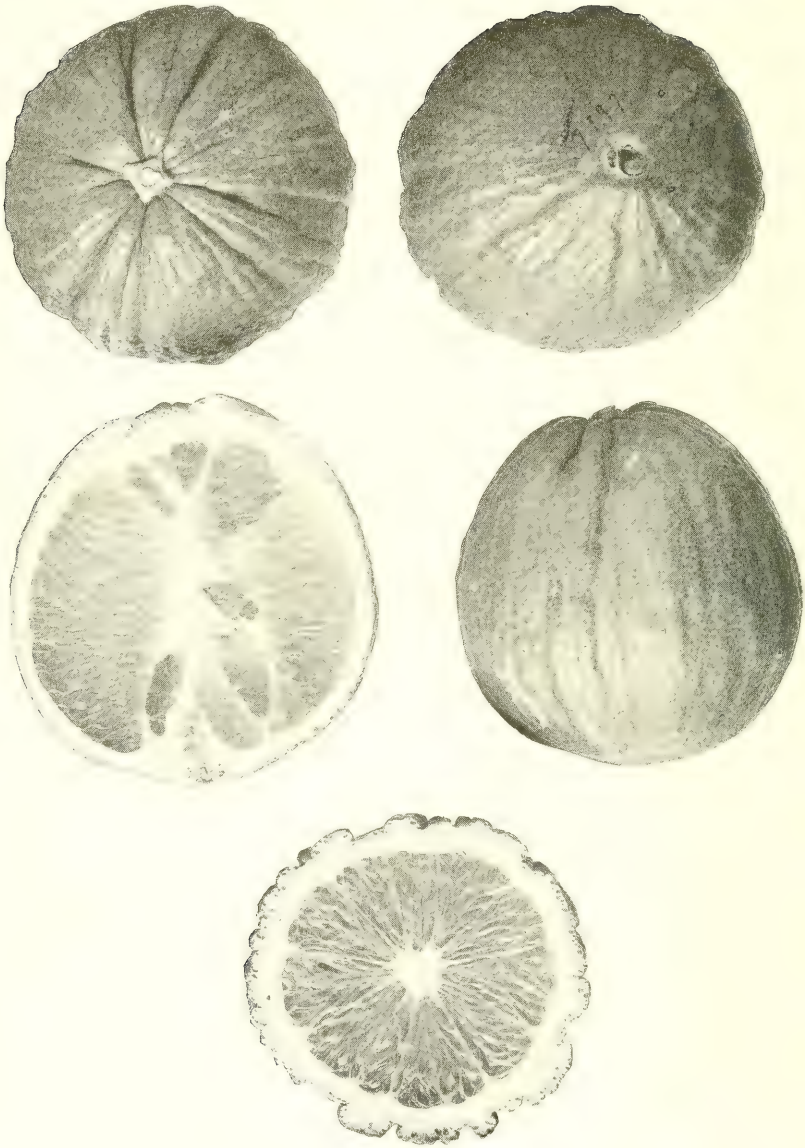
P1037A–HP

TYPICAL FRUITS OF THE PROTRUDING NAVEL STRAIN OF THE WASHINGTON NAVEL ORANGE.



P9343HP AND P9344HP

TYPICAL FRUITS OF THE LONG STRAIN OF THE WASHINGTON NAVEL ORANGE.



P1028A—HP

TYPICAL FRUITS OF THE CORRUGATED STRAIN OF THE WASHINGTON NAVEL ORANGE.

ton trees. The habit of growth is open and drooping and the foliage semidense, in some cases the leaves being rather small and sharply pointed.

The fruits, illustrations of which are shown in Plate VIII, figures 1, 2, and 3, usually are globular in shape and of small to medium size. The rind is thin and has a ribbed appearance, but is fairly smooth. The color usually is dull orange. The rag is tender and small in quantity, and the juice is abundant and of good flavor and quality. The fruit is seedless and the navel small and inconspicuous. The principal objections to this strain from the commercial standpoint are the small size of the fruits and their fluted appearance. The fruits of this strain have been found to occur as occasional individual fruit sports in trees of Washington and other strains, and infrequently as limb sports in Washington and Thomson trees.

PEAR-SHAPE STRAIN.

The trees of the Pear-Shape strain usually are low producers, are finely branched, and have an upright habit of growth and rather sparse foliage of small, sharply pointed leaves.

The fruits, illustrations of which are shown in Plate IX, are pyriform in shape, usually having a rather large collar or neck at the stem end, and are small to medium in size. The rind is rather coarse in texture and usually very thick and is yellowish orange in color. The rag is abundant and frequently coarse and the juice is small in quantity and inferior in quality. The fruits are seedless and the navels usually small. This strain is of inferior commercial value, but of interest from the standpoint of its occurrence as individual fruit and limb variations in trees of the Washington and other strains.

PROTRUDING-NAVEL STRAIN.

One of the interesting strains of the Washington Navel orange is that in which the fruits develop large, secondary oranges, or navels, and large navel openings. The navel formations may be entirely inclosed within the rind of the primary oranges, in which cases the fruits are usually elongated and abnormal in shape, or the secondary fruits may entirely protrude through the navel openings. Fruits with large interior navels are objectionable because they can not be eaten conveniently with a spoon. Fruits with protruding navels are subject to injuries in handling, which frequently lead to decay. The trees of this strain usually show more than ordinarily vigorous vegetative growth and have very large leaves.

The fruits, illustrations of which are shown in Plate X, frequently are irregular in shape and large in size. The coarse, thick rinds are deep orange in color. The rag is coarse and the juice abundant and of fair quality. The fruit is seedless, and the navels very large and

objectionable. Because the character of the development of the navel inside the fruit can not always be determined by outside inspection, and for other reasons, these fruits often are overlooked by graders in the packing house and may be included in the regular pack. This strain is a frequent variation in Washington and Thomson trees.

LONG STRAIN.

The trees of the Long strain are similar in appearance to those of the Washington strain and have about the same characteristics of growth, foliage, and production.

The fruits, illustrations of which are shown in Plate XI, are mainly distinguished from those of the Washington strain by their peculiar long and cylindrical shape, which makes them poorly adapted for packing in the present commercial package. The fruits usually are of small to medium size and in color, texture, and other characteristics of the rind are similar to the Washington strain. The rag is small in quantity and tender, and the juice is abundant and of good quality. The fruits are seedless, and the navels usually are small to medium in size. Fruits of this strain are found frequently as individual fruit or limb sports in Washington and Thomson trees.

CORRUGATED STRAIN.

The trees of the Corrugated strain resemble the Thomson closely in production, habit of growth, and foliage characteristics.

The fruits are very different from those of the other Washington Navel orange strains, being prominently ridged or corrugated, as shown in Plate XII. They usually are globose in shape and of large size. The rind is of medium thickness and the color deep orange. The rag is tender and small in quantity, and the juice is abundant and of good quality. The fruits are seedless and the navels small to medium in size. Fruits of this strain occur as individual fruit or limb variations in trees of the Washington and Thomson strains. On account of the peculiar and prominent marking of the fruits, this strain is one of the most interesting and important of those resulting from the bud variations of the Washington Navel orange. Its rather frequent occurrence and the successful transmission of its characteristics in propagation experiments furnish strong arguments for care in bud selection in the propagation of the citrus varieties.

UNPRODUCTIVE STRAIN.

The trees of the Unproductive strain, an illustration of which is shown in figure 6, have a very low production, are finely branched, and have a spreading habit of growth with sparse foliage. The leaves usually are small, narrow, and sharply pointed. The trees

frequently produce an excessive amount of bloom, nearly all of which drops early in the season, so that only a few fruits develop and reach maturity.

The fruits usually are globose in shape and are either very small or very large in size. The rinds are coarse and thick, of a yellowish orange color. The rag is abundant and coarse, and the juice is scant and of inferior quality. The fruits are seedless and have medium to large navels, many of which protrude. The fruits of the Unproductive strain are almost worthless commercially and where they occur detract seriously from the value of the general crop of the grove.

P752A—HP

FIG. 6.—A typical tree of the Unproductive strain of the Washington Navel orange. The performance record of this tree for four seasons is given in rank 475 in Tables IV and V, and its performance record for six seasons is shown in rank 150 in Tables II and III.

FLATTENED STRAIN.

The trees of the Flattened strain are similar in appearance, habit of growth, and foliage characteristics to those of the Washington strain.

The fruits, illustrations of which are shown in Plate XIII, are of medium size and are flattened at the stem and blossom ends. The rind is bright orange in color, thick, and of a coarse texture. The

rag is of medium quantity and the juice fairly abundant and of fair quality. The fruits are seedless and have navels of ordinary size. The flattened shape of these fruits makes them poorly adapted for packing under prevailing conditions; otherwise, this strain is equally as good as the Washington strain in commercial quality. It occurs as single fruit and limb variations in Washington, Thomson, and other trees and as individual trees.

DRY STRAIN.

In addition to the 13 strains described above, one other, the Dry strain, might be added to this list. The trees show a finely branched arrangement, somewhat resembling that of the Unproductive strain. The habit of growth of the trees is erect and the foliage is dense, with small sharply pointed leaves.

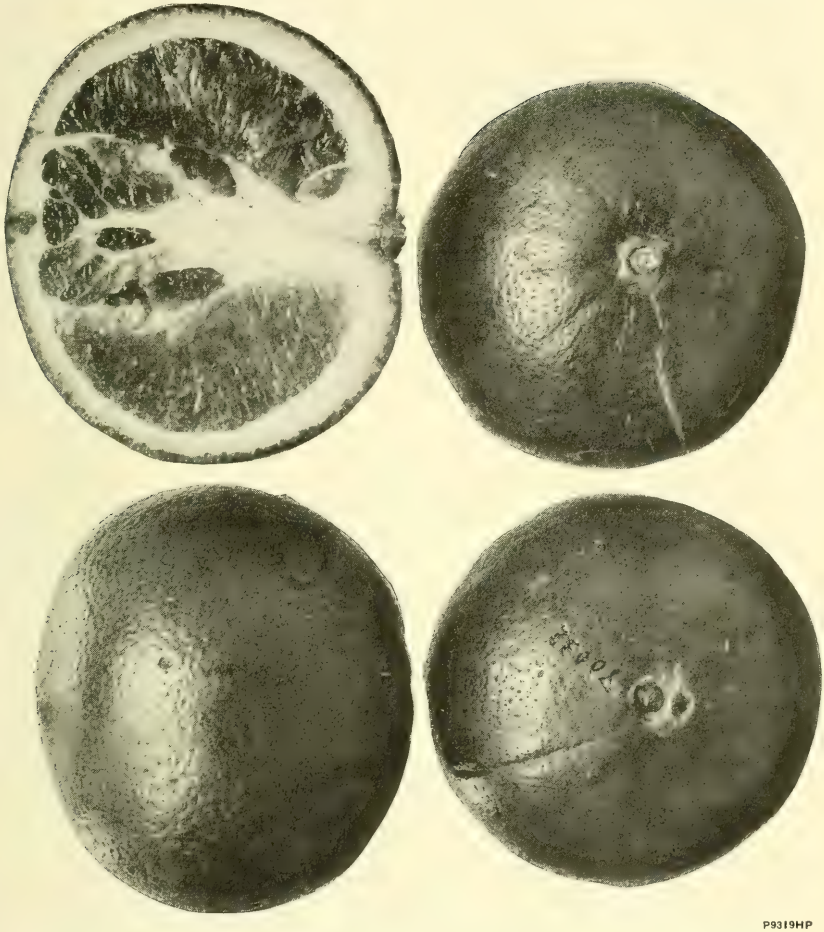
The fruits, illustrations of which are shown in Plate XIV, usually are globular or oblong and of small to medium size; the rinds are very thick and very coarse in texture and usually are yellowish orange in color. The rag is abundant and coarse, and the juice is very scant, often hardly enough to measure, and of very inferior quality. The fruits are seedless and the navels usually medium to large. This strain has been found to occur in some orchards as individual fruit and limb sports in trees of the Washington strain. In some few cases under observation a considerable proportion of the trees in the orchards are of this strain, making the crop as a whole of very inferior commercial value.

INDIVIDUAL FRUIT VARIATIONS.

The individual fruit variations found in the trees of the Washington or other strains are of fundamental importance in considering the origin of the various strains under prevailing conditions.

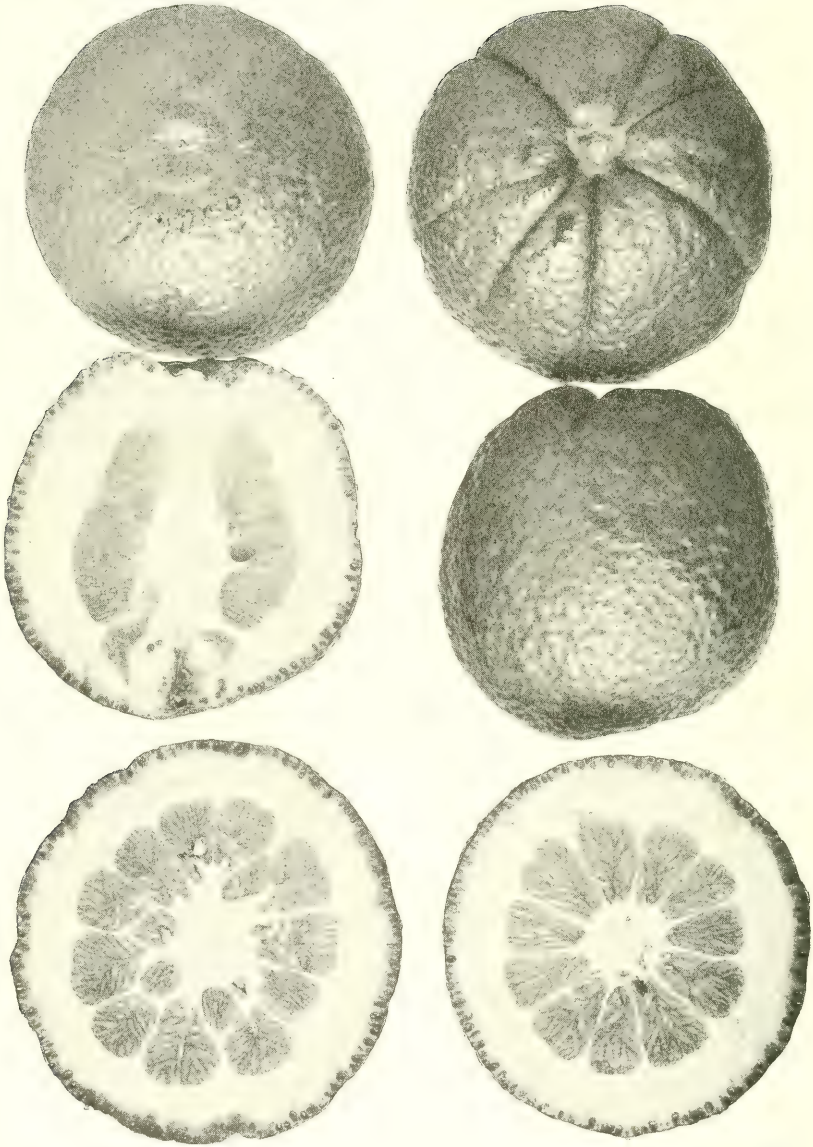
In the first performance-record work with Washington strain trees, it was found during the process of assorting the fruits that occasionally one or more fruits, very distinct and different from the Washington strain, such as those of the Golden Nugget, Australian, or Thomson strain, occurred in the crop. This condition led to a careful study of the occurrence of these fruit variations in trees of the Washington and other strains before picking. It was soon found that these individual fruit variations, such as a Golden Nugget in a Washington strain tree, corresponded in all particulars to the fruits borne by Golden Nugget trees in the orchards in which the performance-record plats were located.

One of the first and most important individual fruit variations observed in Washington strain trees in 1910 in one of the performance-record plats was an Australian fruit. Shortly after the discovery of this single variation in the crop of a Washington performance-record tree, a limb in a near-by Washington tree was found to bear



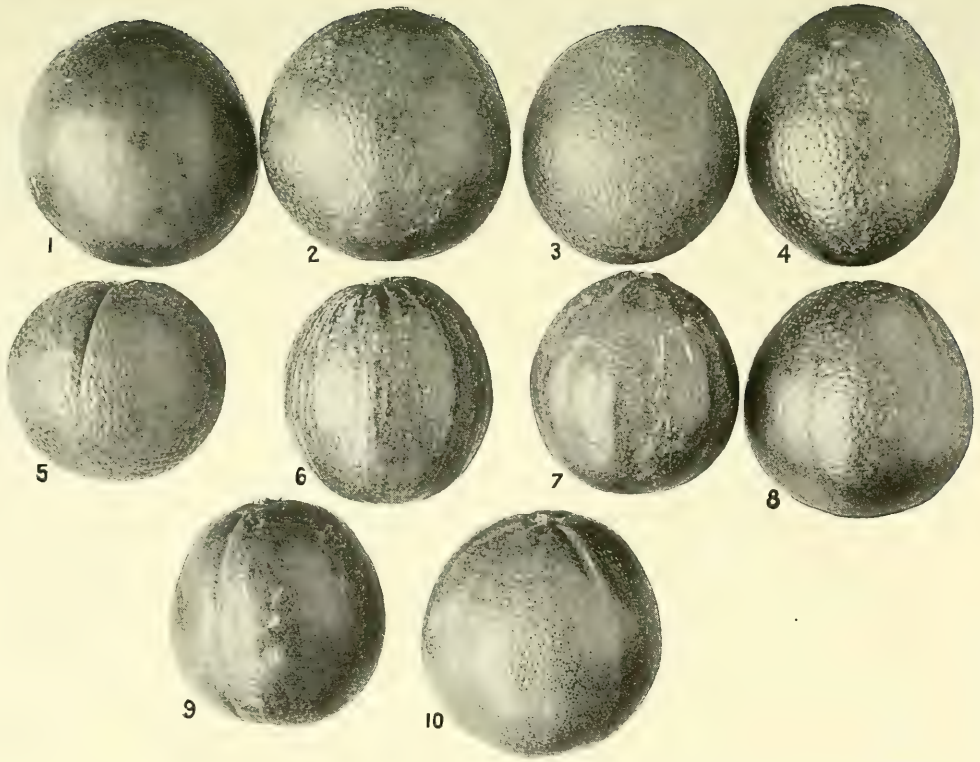
P9319HP

TYPICAL FRUITS OF THE FLATTENED STRAIN OF THE WASHINGTON NAVEL ORANGE.



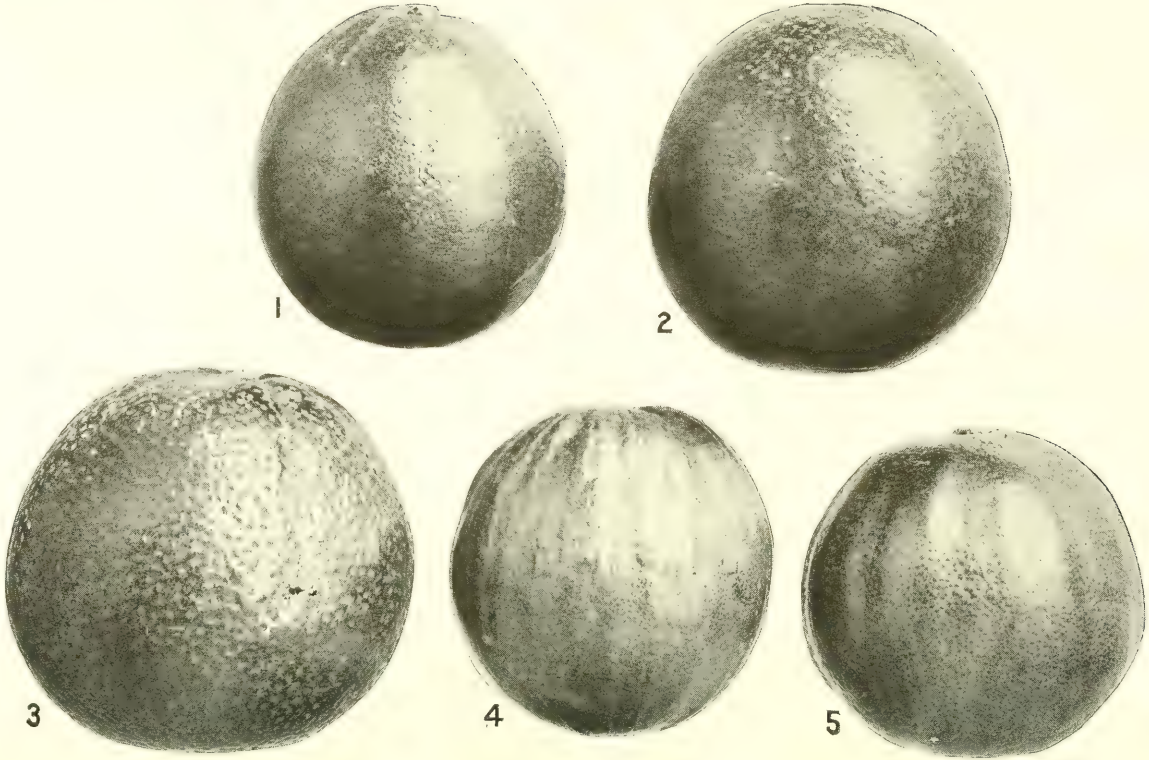
P9326HP

TYPICAL FRUITS OF THE DRY STRAIN OF THE WASHINGTON NAVEL ORANGE.



P1047A–HP

FRUITS OF DIVERSE STRAINS BORNE BY A WASHINGTON NAVEL ORANGE TREE GROWN FROM A SINGLE BUD: 1, THOMSON; 2, GOLDEN NUGGET; 3, WASHINGTON; 4, LONG; 5, FLATTENED; 6, CORRUGATED; 7, RIBBED; 8, RAISED SECTION; 9, CREASED, ONE-THIRD THOMSON AND TWO-THIRDS GOLDEN NUGGET; 10, THREE-FOURTHS THOMSON AND ONE-FOURTH YELLOW THOMSON.



PI063A–HP

TYPICAL SPECIMENS OF THE (1) YELLOW, (2) THOMSON, (3) WASHINGTON, (4) CORRUGATED, AND (5) RIBBED STRAINS OF THE WASHINGTON NAVEL ORANGE BORNE BY LIMB SPORTS IN A TREE GROWN FROM A SINGLE BUD.

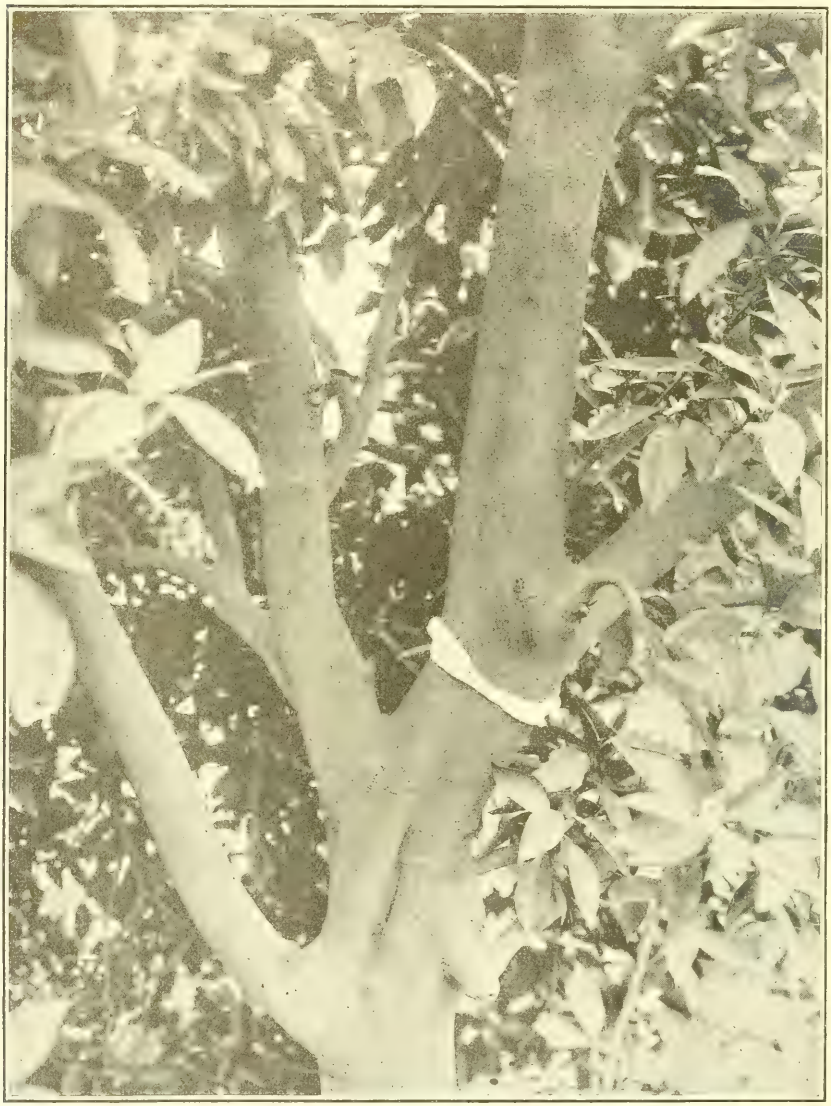
a large number of these typical Australian fruits. A further study of this orchard revealed several trees bearing all or nearly all Australian fruits and having the peculiar upright habit of growth so characteristic of the trees of that strain.

P530A-HP

FIG. 7.—A Washington strain orange tree with a large limb sport of the Unproductive strain (shown at the right).

An investigation of the occurrence of the single-fruit variations found in the Washington trees, as illustrated in Plate XV, revealed their occurrence in other trees as limb sports and in other cases as individual trees. A limb sport of the Unproductive strain occurring

in a Washington strain tree is shown in figures 7 and 8. Typical fruits of the limb sports borne by one tree grown from a single bud are shown in Plate XVI. This condition is conclusive evidence



P541A-HP

FIG. 8.—Trunk and main limbs of the tree shown in figure 7. The branch marked with the band of cloth is the Unproductive strain sport.

that the origin of the diverse strains of trees in Washington Navel orange orchards is due to the accidental propagation of limb sports, and it is an important reason for obtaining performance records for use in the selection of bud wood for propagation.

MINOR VARIATIONS OF FRUITS.

In addition to the widely different strains of the Washington Navel orange discovered in these investigations, many other less striking variations have been observed. The full significance and importance of these minor variations are not fully understood as yet, so that no extended discussion of their occurrence will be given at this time.

Among these variations are those similar to fruit chimeras, an example of which is shown in Plate XVII, figures 1 and 2. In some cases fruits show clearly marked sections of two or more distinct strains. For instance, examples have been found of oranges showing unmistakable Washington sections, with the remainder of the fruits showing the Thomson strain; again, a section possesses Golden Nugget characteristics, while the remainder is the Washington strain to all appearances. In a few cases parts of individual fruits have been observed which are unlike any known strains of the variety, an example of which is shown in Plate XVIII. As a rule, however, in the chimeralike forms studied so far, the variable individual fruit sections have been found to resemble some of the important strains previously described.

In the course of these investigations, many fruits having decidedly abnormal shapes or structures have been observed. For instance, twin oranges or those made up of two almost complete fruits with but a single calyx have been found. Other fruits have been seen which have resembled lemons externally to such an extent that persons not knowing of their occurrence on orange trees have thought them to be lemons. In a few fruits the navel has been found to be developed as a complete secondary orange outside of the primary fruit. Some fruits have been found with a loose rind, like that of the tangerine. A number of oranges have been observed without any apparent navel development but otherwise similar to Washington Navel fruits. A long list of similar cases might be cited, but in the light of our present knowledge of this subject they are apparently of little significance or importance to these investigations. Illustrations of some of these abnormal forms are shown in Plate XIX.

Some of the trees in the performance-record plats have shown but few or none of these minor fruit variations. Other trees have been prolific in the production of such abnormal fruits and these have not been used as sources of bud wood for propagation except for experimental purposes.

LESSONS TAUGHT BY THESE INVESTIGATIONS.

The performance-record data presented in this bulletin constitute but a small part of the records secured in these investigations of the Washington Navel orange. The data shown here have been limited

to such as will, it is thought, illustrate the character and importance of the records. The complete data from the beginning of the investigation until the present time are open for inspection at any convenient time to all interested persons. The publication of the complete data would entail the presentation of such a large number of figures and tables as to make this bulletin cumbersome and in all probability defeat one of the objects of its issue, namely, to interest fruit growers and others in individual-tree performance-record work.

The information gained from these investigational individual-tree performance-record data and related observations made while securing them have been the basis upon which have been developed the present commercial methods of practice in California in securing individual-tree records, in the selection of undesirable trees in established orchards for top-working, and in the choice of trees as sources of bud wood for propagation.

The conclusions presented here have not all been derived from a study of the performance-record data. Some phases of tree and fruit characteristics can not be recorded in figures or reproduced in photographs or other illustrations. These indefinable characteristics are of importance and usually are perceived only by those who have a natural liking for this kind of work. Though the tree records are the foundation upon which has been developed the practice of bud selection described in these pages, other factors, a knowledge of which has been gained from almost daily and continuous contact with the trees and fruits, have been taken into consideration. The instinct enabling an observer to distinguish one strain of tree or fruit from another and to select the best from among many individuals studied during the individual-tree performance-record work is almost, if not equally, as important as the actual tree records themselves. It is an essential and important qualification for anyone who expects to make any standardization through bud selection in the Washington Navel orange or other fruit variety. This point should be emphasized, for although the data secured from the individual-tree records is of the utmost importance from many standpoints, one of its most important uses is for the training of the judgment of the observer. The knowledge of trees and their fruits gained in this systematic manner from continuous and intimate contact with them becomes in time of genuine value in the study of varieties and their variations.

The differences in the characteristics of the various strains of the Washington Navel orange variety are often difficult to describe or illustrate. The behavior of some of these strains, as shown in this bulletin by means of performance records, descriptions, and photographs, is only a part of the story. The real differences of the trees and fruits must be seen before they can be fully appreciated

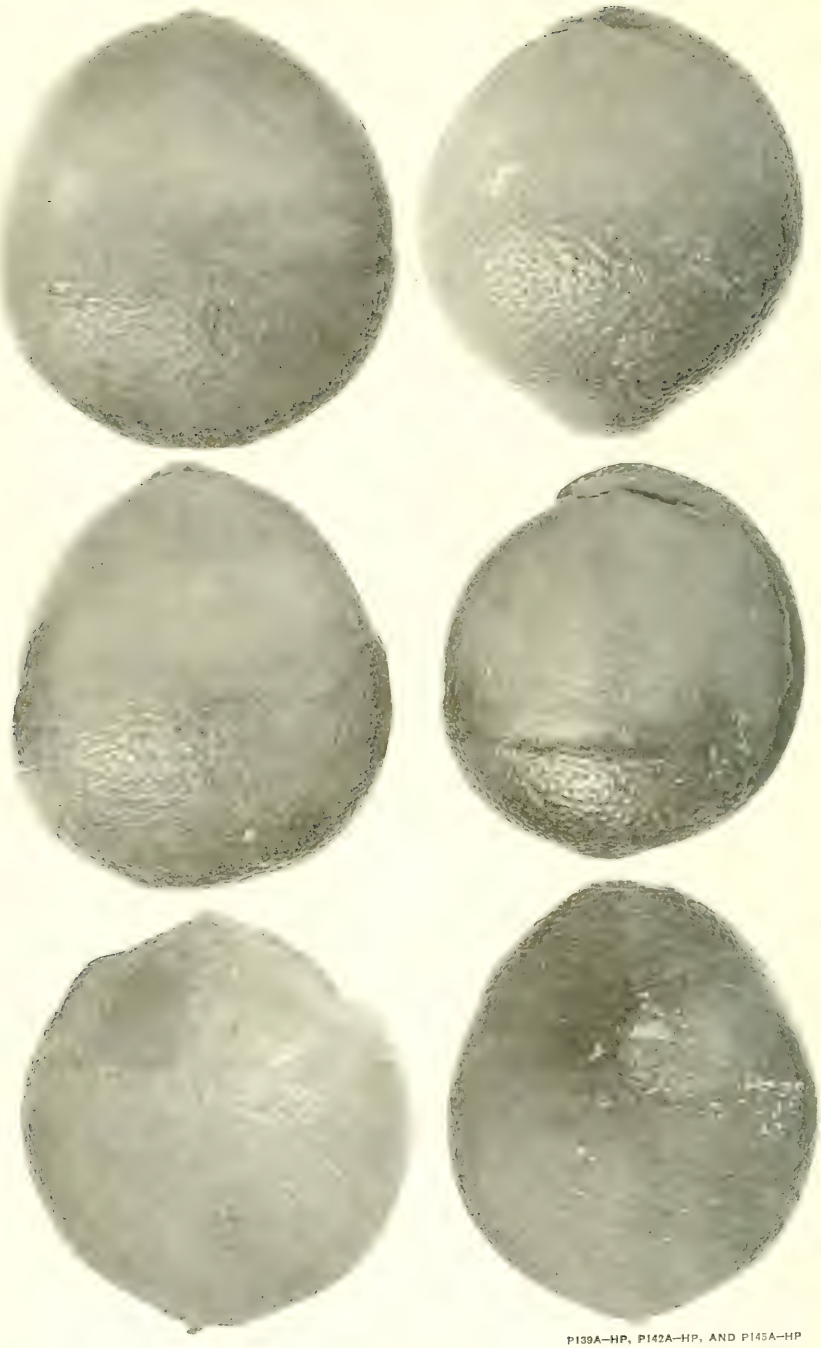
P16060HP

FIG. 1.—SIDE VIEW.

P16062HP

FIG. 2.—AXIAL SECTION.

A WASHINGTON NAVEL ORANGE, SHOWING A CONSPICUOUS DEVELOPMENT AS A RAISED, COARSE SECTION OF THE RIND.



P139A–HP, P142A–HP, AND P145A–HP

WASHINGTON NAVEL ORANGES, SHOWING IRREGULAR AREAS OF VERY SMOOTH RIND, SIMILAR TO THE THOMSON STRAIN, THE REMAINDER BEING THE TYPICAL WASHINGTON STRAIN IN TEXTURE AND APPEARANCE. THESE OCCUR AS LIMB SPORTS IN A TREE WHICH ALSO BEARS FRUITS OF THE WASHINGTON STRAIN.

P339A—HP

WASHINGTON NAVEL ORANGES, SHOWING ABNORMAL SHAPES AND MARKINGS, ALL BORNE ON ONE TREE GROWN FROM A SINGLE BUD.

and their importance in commercial fruit growing understood. With available means it is impossible adequately to present the characteristic differences of the strains so that one unacquainted with them can appreciate and understand them thoroughly.

Within the strains of the Washington Navel orange are marked variations, of importance commercially, but not so striking as the variations which distinguish the strains themselves. These individual-tree differences in the strains should be taken into account by the performance-record keeper and this knowledge utilized in the selection of trees for top-working or for use as sources of bud wood.

Fortunately, as discovered early in the history of these investigations, a marked correlation exists between the quantity and the quality of the fruits produced by the individual trees of the different strains. The most productive trees usually produce the largest proportion of fruits of the first grade and of the most valuable commercial sizes. Usually such trees show the fewest marked variations in fruits from the type of the strain to which they belong. This condition enables the fruit grower to gain from his records of production of the individual trees a reliable conception of their comparative value.

PRESENTATION OF DATA.

All the diagrams and tables presented herewith, with the exceptions noted in the following paragraph, have been prepared from individual-tree performance records of 481 Washington Navel orange trees located in groves planted in 1902 near Riverside, Cal. These records cover the period from 1912 to 1915, inclusive.

Of these performance-record trees, 151 were selected in 1910, so that data for six years have been secured from this number, as shown in Tables II and III. From the tree of the Yellow Thomson strain records have been secured for only three seasons, and from the eight Golden Nugget trees only two seasons' records have been obtained.

The performance-record trees include typical examples of seven of the thirteen most important strains and of four of the minor strains of the Washington Navel orange, as follows: Three hundred and sixty-five Washington, 51 Thomson, 35 Unproductive, 13 Yellow Washington, 8 Golden Nugget, 2 Wrinkled Australian, 1 Yellow Thomson, 4 Thomson-Washington, 2 Sporting Thomson, 1 Sporting Washington, and 1 Washington-Thomson. Examples of the other important strains and of several minor strains occur as individual fruit and limb variations in many of the trees under observation.

The average total crop of each of the trees from which performance records have been obtained for six successive seasons is shown in Table II. The percentage of Orchard (or first grade) fruit produced by each tree is also expressed, being figured on the basis of the weight of the crops, and the proportion of variable fruits, by number, is shown. When securing performance records, late bloom fruit and split fruit have been recorded, but such fruits have not been included with the variable fruits. In Table II the trees are ranked arbitrarily according to their average total crops, by weight, without regard to the grade or quality of the fruit or its uniformity. Hence, the position of any given tree in this table is not necessarily a true index of what its relative position would be if the classification were made on the basis of the commercial value of its fruit. The great number of characteristics of trees and fruit which must necessarily be taken into consideration in attempting a classification of this sort on the basis of the quality of the fruit and the desirability of the individual trees renders such a system inaccurate and unsatisfactory when dealing with such a large number of individuals as are represented here. On this account the basis of average annual yield was adopted.

TABLE II.—*Summarized statement of the average annual production of 151 Washington Navel orange trees for which detailed performance records were obtained for six years, 1910 to 1915, inclusive.*

[Detailed performance records of the trees marked with an asterisk (*) are shown in Table III. Trees marked with a dagger (†) are of the Unproductive strain; all others are of the Washington strain.]

Rank.	Tree designation.	Annual crop production, 6-year average.				Rank.	Tree designation.	Annual crop production, 6-year average.			
		Weight.	Number.	Orchard grade.	Variable fruits.			Weight.	Number.	Orchard grade.	Variable fruits.
		Pounds.		*P. ct.*	*P. ct.*			*Pounds.*		*P. ct.*	*P. ct.*
1	*3-14-27	394.0	771	81.9	0.54	30	10:1-30- 9	262.9	525	84.6	2.48
2	*3-12-28	379.6	878	78.2	.91	31	*10:1-30- 3	261.3	568	87.0	.35
3	3-13-29	354.6	721	80.0	1.28	32	3-17- 4	258.0	560	82.8	.57
4	*3-14-26	350.2	711	85.7	.98	33	10:1-29-10	256.8	568	85.3	.44
5	3-12-29	343.4	709	80.9	.89	34	6:1-58- 1	256.7	623	85.4	.40
6	*3-13-28	341.3	744	81.2	.81	35	10:1-32- 9	255.4	566	84.0	.18
7	*3-12-30	325.2	643	77.2	.98	36	3-14- 4	253.0	504	85.8	1.93
8	*3-14-25	322.7	613	85.8	.78	37	10:1-29- 3	251.9	528	84.2	.76
9	4-27-16	322.7	655	81.2	.76	38	*10:1-28- 8	249.3	575	82.6	.52
10	*7:2-25- 1	311.2	654	84.7	.84	39	10:1-29- 6	248.7	498	82.2	.50
11	*7:2-37- 1	298.8	603	82.6	.46	40	10:1-28- 6	248.1	518	85.2	1.06
12	10:1-29- 8	291.7	591	81.6	1.02	41	10:1-32- 3	247.9	516	85.4	.45
13	4-28-14	291.3	643	83.7	.58	42	7:1-53- 1	247.4	533	83.8	.75
14	*10:1-28- 9	289.1	752	83.9	.47	43	10:1-30- 7	246.1	505	80.8	.85
15	7:2-32- 3	282.6	632	78.7	.44	44	10:1-28- 5	244.9	519	87.8	1.02
16	4-26-13	282.0	601	84.2	1.08	45	10:1-29- 7	244.5	549	85.4	.87
17	7:2-31- 1	281.1	614	83.0	.29	46	10:1-29- 4	242.4	466	83.1	1.57
18	10:1-32- 6	280.6	606	85.4	.38	47	10:1-31- 6	242.4	500	86.4	.86
19	*4-23- 3	280.5	564	83.6	.83	48	4-32- 4	240.7	532	80.8	1.03
20	10:1-29- 2	277.9	658	79.4	.68	49	*10:1-28- 4	240.3	515	85.0	1.03
21	7:2-25- 3	276.4	588	83.6	.31	50	4-23- 2	239.3	479	84.0	.52
22	4-18-19	275.7	633	79.2	.27	51	10:1-32- 7	236.6	501	81.0	.96
23	10:1-31- 7	272.5	610	81.6	.70	52	7:2-31- 3	235.8	508	80.8	.85
24	10:1-31- 5	272.0	544	85.7	.55	53	7:2-30- 4	233.8	485	84.4	.52
25	3-13- 4	272.0	553	82.6	.60	54	10:1-29-11	233.3	584	86.5	.51
26	*10:1-31- 4	269.0	561	84.4	.62	55	10:1-30- 5	232.9	427	87.2	1.17
27	10:1-32- 4	268.4	553	83.8	.63	56	10:1-30- 2	232.7	509	84.8	2.02
28	10:1-31-10	266.2	580	82.0	.86	57	4-18-18	230.6	516	82.0	.87
29	10:1-32-10	263.2	557	83.4	.45	58	*4-30- 6	229.8	452	82.3	2.39

TABLE II.—*Summarized statement of the average annual production of 151 Washington Navel orange trees for which detailed performance records were obtained for six years, 1910 to 1915, inclusive*—Continued.

Rank.	Tree designation.	Annual crop production, 6-year average.				Rank.	Tree designation.	Annual crop production, 6-year average.			
		Weight.	Number.	Orchard grade.	Variable fruits.			Weight.	Number.	Orchard grade.	Variable fruits.
		Pounds.		*P. ct.*	*P. ct.*			*Pounds.*		*P. ct.*	*P. ct.*
59	10:1-28- 3	229.5	488	82.6	0.72	106	7:1-69- 8	150.6	444	80.3	0.90
60	10:1-28-10	227.6	510	84.6	.69	107	*7:1-65- 6	149.8	384	79.6	.52
61	4-21-31	224.6	484	79.8	.52	108	7:1-66-11	148.1	404	76.6	.32
62	4-29- 6	224.0	451	82.2	1.55	109	7:1-69-12	145.4	426	79.6	1.24
63	10:1-30- 1	223.9	489	85.5	.37	110	7:1-65- 7	144.0	371	80.4	.54
64	10:1-31- 1	223.8	487	83.8	.78	111	7:1-65-15	143.3	371	81.6	.49
65	10:1-31- 2	223.3	462	81.6	.61	112	*7:1-65-14	143.1	359	82.4	1.06
66	4-21-30	222.9	480	81.6	.25	113	7:1-66- 9	136.8	376	83.2	.61
67	*10:1-31- 9	220.7	435	83.4	1.26	114	7:1-66-13	136.4	345	80.2	1.30
68	10:1-30- 8	218.7	454	83.6	1.50	115	7:1-65- 9	134.7	363	82.0	.36
69	10:1-28- 2	218.3	468	83.2	.43	116	7:1-69-15	131.5	351	80.2	.28
70	4-17-34	217.5	460	79.6	.80	117	*7:1-69-10	128.6	364	82.0	1.10
71	10:1-32-11	217.4	451	86.4	.84	118	7:1-67-11	127.3	365	84.0	.36
72	10:1-32- 5	216.1	433	85.4	.42	119	7:1-66-15	126.4	333	82.2	.84
73	10:1-32- 8	215.9	449	83.6	2.52	120	7:1-66-14	122.6	349	79.4	.72
74	4-31- 2	214.4	454	78.6	.77	121	*7:1-66- 6	119.4	325	76.4	.92
75	10:1-31- 3	214.1	438	85.0	.80	122	7:1-69-14	118.7	312	79.6	.48
76	10:1-31- 8	211.0	433	83.8	.88	123	7:1-68-11	118.6	328	76.8	.85
77	3-14- 3	211.0	434	85.6	.85	124	7:1-69- 7	116.3	329	72.6	1.15
78	*10:1-28- 1	209.5	451	82.0	1.11	125	7:1-67-14	113.0	317	82.3	.57
79	4-23-28	209.4	465	79.6	.86	126	7:1-65-11	112.0	307	80.0	.81
80	10:1-31-11	208.3	479	82.6	1.00	127	7:1-69- 9	111.6	327	75.2	1.38
81	7:1-65-21	207.6	548	80.0	.55	128	7:1-66- 7	111.5	291	79.8	.69
82	10:1-32- 2	207.1	425	83.0	.78	129	7:1-67-10	111.4	317	79.0	.41
83	6:1-70- 9	205.6	476	86.0	.21	130	*7:1-67-15	110.1	318	78.8	.72
84	10:1-28-11	204.4	458	85.2	1.48	131	*†7:1-68- 7	108.0	319	73.4	.63
85	10:1-29- 5	202.4	430	85.2	.47	132	7:1-66- 8	106.4	308	76.3	.42
86	7:1-65-22	201.9	560	80.4	.59	133	7:1-65-12	105.6	293	81.6	.85
87	4-30- 5	201.3	393	80.6	1.27	134	7:1-68-15	105.2	284	78.3	1.51
88	*10:1-32- 1	201.2	435	82.2	.64	135	7:1-68- 6	104.4	297	74.6	1.11
89	10:1-29- 1	197.0	427	83.6	1.36	136	*7:1-68-13	100.8	284	78.2	.46
90	10:2- 7-13	195.5	419	78.6	.36	137	*†7:1-67-12	100.2	272	71.8	.11
91	4- 3- 6	193.0	344	82.6	.44	138	†7:1-68- 9	100.2	308	74.8	1.47
92	10:1-30- 4	192.7	388	83.0	.64	139	†7:1-67- 8	99.6	292	78.6	.51
93	*10:1-29- 9	188.0	379	85.0	.40	140	†7:1-67- 7	98.2	278	77.4	.90
94	4-31- 3	187.3	402	77.2	1.69	141	*†7:1-68-10	92.5	267	75.8	.75
95	10:1-30- 6	186.3	369	83.6	.81	142	†7:1-67- 9	85.5	252	69.6	3.37
96	4-17-16	183.6	348	79.2	.57	143	†7:1-67- 6	84.3	243	80.8	1.44
97	*4-18- 1	176.7	316	83.2	1.17	144	†7:1-68-14	83.1	239	73.0	.63
98	7:1-65- 8	173.7	468	84.8	.43	145	*†7:1-68- 8	78.5	217	72.6	.37
99	10:1-28- 7	173.7	339	83.6	1.71	146	†7:1-68-12	76.5	224	74.0	.58
100	*7:1-65-10	172.8	431	81.6	1.16	147	†7:1-66-12	72.6	198	65.2	2.52
101	7:1-69- 6	164.4	450	76.6	.40	148	*†7:1-67-13	69.5	198	76.3	.40
102	7:1-65-13	162.6	442	78.6	.45	149	†7:1-66-10	68.6	180	73.6	.17
103	*7:1-69-11	161.3	442	81.8	.52	150	*†7:1-65-23	62.7	178	75.2	1.40
104	10:1-30-11	153.8	344	84.2	1.98	151	*†7:1-52- 3	55.8	119	63.0	1.68
105	7:1-69-13	152.1	405	84.8	.25						

Table II shows not only the great variations in the average quantity of fruit produced by different individual trees, but also the percentages of the Orchard grade, or first-grade, fruit. The number of variable fruits shows the variations in the uniformity of the fruit.

To indicate more fully and accurately the real variations between the different trees and their true relative values to the investigator and the orchardist, it is necessary to consider the yearly record of each tree.

The complete performance records of 35 representative trees of the 151 on which data have been secured for six years are given in Table III. This list was made by selecting within each strain those trees whose average total crops were nearest the multiples of 10 pounds. This basis was adopted in order to remove all chance for any personal bias in the selection of the trees.

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II.*

[The weights of annual production are expressed in pounds and ounces, but the fractional averages are expressed decimally in pounds.]

Rank in Table II, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
1. Washington strain:																							
Orchard grade—																							
1910	382- 7	738																					
1911	271-14	385	0- 4	1	0- 0	0	0-12	2	1-10	4	4-10	10	27- 9	52	6-11	12	54- 4	86	90-10	124	85- 8	94	....
1912	315- 0	581	1- 5	5	2- 8	8	4- 5	12	27-13	68	29- 1	64	84- 5	163	28-15	52	77-14	128	41- 0	59	17-14	22	....
1913	152-14	310	0- 4	1	0- 5	1	7- 7	23	13-10	37	25- 3	59	34-14	72	41-14	74	14-11	23	6-14	10	7-12	10	....
1914	461- 8	946	1-10	8	5- 6	19	19-14	59	51-15	133	126-10	277	125 12	238	99- 6	167	21-14	33	8- 4	11	0 13	1	....
1915	352- 2	661	0- 0	0	0- 9	2	4-12	14	16- 4	43	36- 5	85	62-13	130	120- 9	217	57-13	94	34- 5	51	18-12	25	....
Average	**322.6**	**604**	**0.7**	**3**	**1.8**	**6**	**7.4**	**22**	**22.3**	**57**	**44.4**	**99**	**67.1**	**131**	**59.5**	**104**	**45.3**	**73**	**36.2**	**51**	**26.1**	**30**	....
Standard grade—																							
1910	7-10	19																					
1911	27-15	45	0- 0	0	0- 0	0	0- 0	0	0-14	2	1- 7	3	7-14	14	1-12	3	7-14	12	8- 2	11	0- 0	0	....
1912	23-11	57	2- 0	9	1-10	5	2-11	7	4-14	12	3-10	8	5-12	11	1- 3	2	1-15	3	0- 0	0	0- 0	0	....
1913	34- 7	80	0- 3	1	1- 8	5	3-10	11	2- 0	6	7- 3	18	12- 8	26	3- 3	6	1- 2	2	3- 2	5	0- 0	0	....
1914	24- 7	58	1- 1	6	0-15	3	2-10	7	2-12	7	6-12	16	4- 9	9	4- 8	8	1- 4	2	0- 0	0	0- 0	0	....
1915	78-12	151	0- 5	2	0- 9	2	2- 5	7	2- 4	6	5- 2	13	16- 8	35	19- 2	35	15- 6	26	11-14	18	5- 5	7	....
Average	**32.8**	**68**	**0.7**	**4**	**0.9**	**3**	**2.3**	**6**	**2.6**	**7**	**4.8**	**12**	**9.4**	**19**	**6.0**	**11**	**5.4**	**9**	**4.6**	**7**	**1.1**	**1**	....
Cull fruits—																							
1910	0- 0	0																					
1911	23-14	38																					
1912	16- 3	41																					
1913	103-12	311																					
1914	17- 4	38																					
1915	69-13	165																					
Average	**38.5**	**99**																					

Total crop—																								
1910	390- 1	757	2- 9	10	11-12	36	15- 8	41	48-11	117	66-10	141	98- 0	189	28-14	49	70-11	111	28- 7	40	18-15	23	....	
1911	324- 5	468	0- 4	1	0- 0	0	0-12	2	2- 8	6	6- 1	13	35- 7	66	8- 7	15	62- 2	98	98-12	135	85- 8	94	....	
1912	354-14	679	3- 5	14	4- 2	13	7- 0	19	32-11	80	32-11	72	90- 1	174	30- 2	54	79-13	131	41- 0	59	17-14	22	0	
1913	291- 1	701	0- 7	2	1-13	6	11- 1	34	15-10	43	32- 6	77	47- 6	98	45- 1	80	15-13	25	10- 0	15	7-12	10	0	
1914	503- 3	1,042	2-11	14	6- 5	22	22- 8	66	54-11	140	133- 6	293	130- 5	247	103-14	175	23- 2	35	8- 4	11	0-13	1	8	
1915	500-11	977	0- 5	2	1- 2	4	7- 1	21	18- 8	49	41- 7	98	79- 5	165	139-11	252	73- 3	120	46- 3	69	24- 1	32	9	
Average	**394.0**	**771**	**1.6**	**7**	**4.2**	**14**	**10.6**	**30**	**28.8**	**73**	**52.1**	**116**	**80.1**	**156**	**59.3**	**104**	**54.1**	**87**	**38.8**	**55**	**25.8**	**30**	**4**	
2. Washington strain:																								
Orchard grade—																								
1910	319- 7	620																						
1911	212- 2	321	0- 4	1	0- 5	1	0-12	2	2- 7	6	5- 1	11	22-15	45	7- 4	13	52-10	87	61-12	88	57-12	67	....	
1912	317- 3	744	6-12	26	24- 5	78	29- 7	84	74- 0	186	64-12	145	74- 9	150	10- 9	20	29- 7	50	3- 6	5	0- 0	0	....	
1913	225- 5	564	2- 3	10	9-11	38	30- 0	97	39-14	109	62- 6	151	42-14	90	33- 2	61	3- 2	5	1- 5	2	0-12	1	....	
1914	435- 6	1,083	5- 9	26	27- 0	93	69-12	208	85- 6	224	128- 3	298	85-15	176	29-10	52	3- 4	5	0-11	1	0- 0	0	....	
1915	270-14	599	0- 0	0	1- 5	5	11- 0	36	24- 7	69	62- 5	154	59-14	130	78- 3	150	19- 9	33	11-15	19	2- 4	3	....	
Average	**296.7**	**655**	**3.0**	**13**	**12.5**	**43**	**28.2**	**85**	**45.2**	**119**	**64.5**	**152**	**57.2**	**118**	**31.8**	**59**	**21.6**	**36**	**15.8**	**23**	**12.2**	**14**	....	
Standard grade—																								
1910	8- 6	21																						
1911	33-12	57	0- 0	0	0- 0	0	0-12	2	1-10	4	1-14	4	8- 8	16	1- 2	2	6- 0	10	13-14	19	0- 0	0	....	
1912	24- 2	75	8- 5	36	2-14	9	2- 9	7	3- 0	8	2-10	6	3- 0	6	1- 2	2	0-10	1	0- 0	0	0- 0	0	....	
1913	69- 1	212	9- 4	46	9- 8	35	13-14	43	6- 0	17	15- 6	39	9- 2	21	3- 8	7	2- 7	4	0- 0	0	0- 0	0	....	
1914	40- 6	116	4- 3	22	5-13	19	9-15	28	7- 3	18	6-15	16	5- 5	11	1- 0	2	0- 0	0	0- 0	0	0- 0	0	....	
1915	141-15	326	1-15	10	3- 4	12	8-10	27	11- 3	32	20- 5	52	49- 0	107	23- 0	44	13- 3	24	10- 0	16	1- 7	2	....	
Average	**52.9**	**134**	**4.7**	**23**	**4.3**	**15**	**7.2**	**21**	**5.8**	**16**	**9.4**	**23**	**15.0**	**32**	**6.0**	**11**	**4.5**	**8**	**4.8**	**7**	**0.3**	**0.4**	....	
Cull fruits—																								
1910	0- 0	0																						
1911	61-12	109																						
1912	14- 2	47																						
1913	65- 6	251																						
1914	8-13	28																						
1915	30-14	97																						
Average	**30. 1**	**89**																						
Total crop—																								
1910	327-13	641	1- 8	7	6- 2	19	10- 6	30	33- 1	81	53- 8	116	96- 2	186	28- 4	50	68- 0	110	21-12	31	9- 2	11	....	
1911	306-10	487	0- 4	1	0- 5	1	1- 8	4	4- 1	10	6-15	15	31- 7	61	8- 6	15	58-10	97	75-10	107	57-12	67	....	
1912	355- 7	866	15- 1	62	27- 3	87	32- 0	91	77- 0	194	67- 6	151	77- 9	156	11-11	22	30- 1	51	3- 6	5	0- 0	0	0	
1913	359-12	1,027	11- 7	56	19- 3	73	43-14	140	45-14	126	77-12	190	52- 0	111	36-10	68	5- 9	9	1- 5	2	0-12	1	6	
1914	484- 9	1,227	9-12	48	32-13	112	79-11	236	92- 9	242	135- 2	314	91- 4	187	30-10	54	3- 4	5	0-11	1	0- 0	0	11	
1915	443-11	1,022	1-15	10	4- 9	17	19-10	63	35-10	101	82-10	206	108-14	237	101- 3	194	32-12	57	21-15	35	3-11	5	15	
Average	**379.6**	**878**	**6.7**	**31**	**15.0**	**52**	**31.2**	**94**	**48.0**	**126**	**70.5**	**165**	**76.2**	**156**	**36.1**	**67**	**33.1**	**55**	**20.8**	**30**	**11.9**	**14**	**8**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
4. Washington strain:																							
Orchard grade—																							
1910	369–10	717																					
1911	332–11	474	0– 0	0	0– 0	0	0– 6	1	0–14	2	5–10	12	25– 5	48	8–14	16	70– 0	113	124– 4	172	97– 6	110	....
1912	257–10	496	0–12	3	4– 7	14	5–11	16	19– 3	49	27–12	62	70–14	142	14– 9	27	68– 3	115	35– 0	53	11– 3	15	....
1913	143– 7	328	0– 7	2	2– 4	9	17– 4	54	15– 6	39	32– 8	79	35– 1	74	26–10	50	5– 1	8	7– 6	11	1– 8	2	....
1914	393–12	891	0–14	4	6– 4	22	29– 2	86	63– 0	166	130– 4	298	102– 6	207	49– 7	89	11– 0	17	0–11	1	0–12	1	....
1915	303– 7	596	0– 0	0	0– 4	1	3– 9	11	8–14	24	39–14	94	77–11	163	106–11	197	41–13	69	21– 1	32	3–10	5	....
Average	**300.1**	**584**	**0.4**	**2**	**2.6**	**9**	**11.2**	**34**	**21.5**	**56**	**47.2**	**109**	**62.3**	**127**	**41.2**	**76**	**39.2**	**64**	**37.7**	**54**	**22.9**	**27**	....
Standard grade—																							
1910	9– 8	25																					
1911	24– 5	46	0– 0	0	0– 0	0	0– 0	0	2– 0	5	4– 1	9	7– 6	14	2– 4	4	8–10	14	0– 0	0	0– 0	0	....
1912	16– 2	38	0–12	4	1– 0	3	0–12	2	4– 2	10	4– 3	9	3–10	7	1– 1	2	0–10	1	0– 0	0	0– 0	0	....
1913	53– 3	135	3– 0	13	3–15	14	4–10	15	4–10	13	9–13	26	15–15	34	4– 7	9	1–12	3	3–12	6	1– 5	2	....
1914	21– 8	60	1– 7	9	2– 0	7	3–12	11	3– 1	8	4–13	12	2– 4	5	3– 0	6	0– 9	1	0–10	1	0– 0	0	....
1915	50– 9	104	0– 3	1	0– 4	1	1–11	5	1– 9	4	7– 7	18	13–14	30	12– 2	23	7–12	13	5–11	9	0– 0	0	....
Average	**29.2**	**68**	**1.1**	**5**	**1.4**	**5**	**2.2**	**7**	**3.1**	**8**	**6.1**	**15**	**8.6**	**18**	**4.6**	**9**	**3.9**	**6**	**2.0**	**3**	**0.3**	**0.4**	**0.6**
ull fruits—																							
1910	0– 0	0																					
1911	20– 4	29																					
1912	10– 7	33																					
1913	61– 3	202																					
1914	4–12	16																					
1915	29– 0	76																					
Average	**20.9**	**59**																					

Total crop—																								
1910	379- 2	742	2- 4	10	9-14	29	12- 9	35	50-15	125	53- 0	116	101- 8	194	36-10	63	71-10	114	19-10	29	21- 2	27	....	
1911	377- 4	549	0- 0	0	0- 0	0	0- 6	1	2-14	7	9-11	21	32-11	62	11- 2	20	78-10	127	124- 4	172	97- 6	110	....	
1912	284- 3	567	1- 8	7	5- 7	17	6- 7	18	23- 5	59	31-15	71	74- 8	149	15-10	29	68-13	116	35- 0	53	11- 3	15	3	
1913	257-13	665	3- 7	15	6- 3	23	21-14	69	20- 0	52	42- 5	105	51- 0	108	31- 1	59	6-13	11	11- 2	17	2-13	4	1	
1914	420- 0	967	2- 5	13	8- 4	29	32-14	97	66- 1	174	135- 1	310	104-10	212	52- 7	95	11- 9	18	1- 5	2	0-12	1	6	
1915	383- 0	776	0- 3	1	0- 8	2	5- 4	16	10- 7	28	47- 5	112	91- 9	193	118-13	220	49- 9	82	26-12	41	3-10	5	18	
Average	**350.2**	**711**	**1.6**	**8**	**5.1**	**17**	**13.2**	**39**	**28.9**	**74**	**53.2**	**123**	**76.0**	**153**	**44.3**	**81**	**47.8**	**78**	**36.4**	**52**	**22.8**	**27**	**7**	
6. Washington strain:																								
Orchard grade—																								
1910	281-15	550																						
1911	274- 0	386	0- 0	0	0- 6	1	0- 0	0	0-14	2	5-10	12	21-10	41	9-13	17	40-12	66	111-10	154	83- 5	93	....	
1912	268- 2	585	4- 8	16	14-10	45	17-13	50	49- 1	121	45-13	102	73- 4	145	12- 2	22	37- 9	63	9- 6	16	4- 0	5	....	
1913	184-12	469	1-11	8	4- 5	15	27- 4	89	31-11	86	54-10	136	40- 9	89	23- 7	44	1- 3	2	0- 0	0	0- 0	0	....	
1914	369- 2	875	3-10	17	10-11	37	37- 6	112	63-12	170	133- 0	307	79-10	161	36- 0	63	4- 6	7	0-11	1	0- 0	0	....	
1915	286- 0	580	0- 0	0	1- 7	5	3-14	12	12-10	35	43- 6	106	62- 8	137	73- 9	144	41- 5	71	31- 1	48	16- 4	22	....	
Average	**277.3**	**574**	**2.0**	**8**	**6.3**	**21**	**17.3**	**53**	**31.6**	**83**	**56.5**	**133**	**55.5**	**115**	**31.0**	**58**	**25.0**	**42**	**30.1**	**44**	**20.7**	**24**	....	
Standard grade—																								
1910	7- 9	20																						
1911	21- 2	36	0- 4	1	0- 0	0	0- 0	0	0-12	2	1-14	4	2-11	5	1-11	3	8-12	14	5- 2	7	0- 0	0	....	
1912	21-10	67	6- 7	29	1-13	6	3- 3	9	3-13	10	2- 3	5	3-10	7	0- 0	0	0- 9	1	0- 0	0	0- 0	0	....	
1913	52- 5	138	1-15	9	2-13	10	7- 4	23	4- 8	13	12- 7	32	13-12	32	7- 8	15	1- 8	3	0-10	1	0- 0	0	....	
1914	31-12	85	2-10	14	1-14	6	5-10	16	4- 6	11	9- 7	22	6- 3	13	1-10	3	0- 0	0	0- 0	0	0- 0	0	....	
1915	109-10	241	1- 3	9	1- 5	5	5-12	18	5- 5	15	14- 5	36	30- 9	67	23- 4	45	12-15	23	11- 6	18	3-10	5	....	
Average	**40.7**	**98**	**2.5**	**12**	**1.6**	**5**	**4.4**	**13**	**3.8**	**10**	**8.1**	**20**	**11.4**	**25**	**6.8**	**13**	**4.8**	**8**	**2.9**	**5**	**0.7**	**1**	....	
Cull fruits—																								
1910	0- 0	0																						
1911	16- 6	26																						
1912	11- 2	38																						
1913	60- 7	209																						
1914	5-10	17																						
1915	46- 0	140																						
Average	**23.3**	**72**																						
Total crop—																								
1910	289- 8	570	3- 2	14	11- 3	35	12- 6	35	30- 6	75	37- 0	80	76- 1	145	26- 2	46	53- 3	86	22- 5	32	17-12	22	....	
1911	311- 8	448	0- 4	1	0- 6	1	0- 0	0	1-10	4	7- 8	16	24- 5	46	11- 8	20	49- 8	80	116-12	161	83- 5	93	....	
1912	300-14	690	10-15	45	16- 7	51	21- 0	59	52-14	131	48- 0	107	76-14	152	12- 2	22	38- 2	64	9- 6	16	4- 0	5	0	
1913	297- 8	816	3-10	17	7- 2	25	34- 8	112	36- 3	99	67- 1	168	54- 5	121	30-15	59	2-11	5	0-10	1	0- 0	0	1	
1914	406- 8	977	6- 4	31	12- 9	43	43- 0	128	68- 2	181	142- 7	329	85-13	174	37-10	66	4- 6	7	0-11	1	0- 0	0	4	
1915	441-10	961	1- 3	9	2-12	10	9-10	30	17-15	50	57-11	142	93- 1	204	96-13	189	54- 4	94	42- 7	66	19-14	27	19	
Average	**341.3**	**744**	**4.2**	**19**	**8.4**	**28**	**20.1**	**61**	**34.5**	**90**	**60.0**	**140**	**68.4**	**140**	**35.9**	**67**	**33.7**	**56**	**32.1**	**46**	**20.7**	**25**	**6**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Total.		Sizes. 288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
7. Washington strain:																							
Orchard grade—																							
1910	302- 7	548																					
1911	214- 1	299	0- 0	0	0- 0	0	0- 6	1	0- 0	0	2- 6	5	22- 4	42	5- 3	9	41-14	66	69-14	96	72- 2	80	
1912	257- 3	501	2- 9	9	6-13	21	9-15	27	25- 4	62	34- 8	75	66- 7	130	15- 8	28	52- 5	87	33- 0	48	10-14	14	
1913	113-14	235	0- 0	0	1- 7	5	3- 9	11	12- 7	33	22- 3	52	26- 5	53	30- 0	54	10-11	17	2-12	4	4- 8	6	
1914	401- 9	915	2-14	13	13- 8	46	48- 4	140	66-13	169	127- 9	284	98-15	190	38- 4	65	5- 6	8	0- 0	0	0- 0	0	
1915	217-14	383	0- 0	0	0- 0	0	0-10	2	3- 0	8	13- 6	31	26- 2	54	70- 9	136	42-12	67	38-15	57	22- 8	28	
Average	**251.2**	**480**	**1.1**	**4**	**4.4**	**14**	**12.8**	**36**	**21.5**	**54**	**10.0**	**89**	**48.0**	**94**	**31.9**	**58**	**30.6**	**49**	**28.9**	**41**	**22.0**	**26**	
Standard grade—																							
1910	9- 6	21																					
1911	18- 9	29	0- 0	0	0- 0	0	0- 0	0	0-14	2	2- 8	5	2-10	5	1- 2	2	7- 0	10	4- 7	5	0- 0	0	
1912	13- 5	34	2- 1	9	1-14	6	1- 0	3	1-12	4	1- 7	3	2-11	5	0-10	1	1-14	3	0- 0	0	0- 0	0	
1913	35-12	82	0- 6	2	2-14	10	3-13	11	1- 9	4	6- 7	16	9-14	21	4- 5	8	3- 2	5	3- 6	5	0- 0	0	
1914	39-12	107	3- 3	17	5- 8	18	6-13	19	6- 6	16	5- 6	12	11- 6	23	1- 2	2	0- 0	0	0- 0	0	0- 0	0	
1915	93-12	167	0- 0	0	0- 0	0	1-15	6	2- 5	6	5- 0	12	18- 5	38	22- 0	40	18- 3	30	21-14	30	4- 2	5	
Average	**35.1**	**73**	**1.1**	**6**	**2.1**	**7**	**2.7**	**8**	**2.6**	**6**	**4.2**	**10**	**9.0**	**18**	**5.8**	**11**	**6.0**	**10**	**5.9**	**8**	**0.8**	**1**	
Cull fruits—																							
1910	0- 0	0																					
1911	52- 0	80																					
1912	15-14	42																					
1913	68- 9	204																					
1914	10- 4	30																					
1915	87- 1	185																					
Average	**39.0**	**90**																					

Total crop—																								
1910	311-13	569	2- 0	8	4- 1	13	6- 7	18	41- 2	96	44- 4	92	72- 8	132	29- 7	49	61- 6	96	32- 6	43	18- 4	22	....	
1911	284-10	408	0- 0	0	0- 0	0	0- 6	1	0-14	2	4-14	10	24-14	47	6- 5	11	48-14	76	74- 5	101	72- 2	80	....	
1912	286- 6	577	4-10	18	8-11	27	10-15	30	27- 0	66	35-15	78	69- 2	135	16- 2	29	54- 3	90	33- 0	48	10-14	14	1	
1913	218- 3	521	0- 6	2	4- 5	15	7- 6	22	14- 0	37	28-10	68	36- 3	74	34- 5	62	13-13	22	6- 2	9	4- 8	6	5	
1914	451- 9	1,052	6- 1	30	19- 0	64	55- 1	159	73- 3	185	132-15	296	110- 5	213	39- 6	67	5- 6	8	0- 0	0	0- 0	0	7	
1915	398-11	735	0- 0	0	0- 0	0	2- 9	8	5- 5	14	18- 6	43	44- 7	92	92- 9	176	60-15	97	60-13	87	26-10	33	12	
Average	**325.2**	**643**	**2.2**	**10**	**6.0**	**20**	**13.8**	**39**	**26.9**	**67**	**44.2**	**98**	**59.6**	**115**	**36.3**	**65**	**40.7**	**65**	**34.4**	**48**	**22.1**	**26**	**6**	
8. Washington strain:																								
Orchard grade—																								
1910	426-11	802																						
1911	313-14	434	0- 0	0	0- 0	0	0- 0	0	0-14	2	7- 7	16	24- 0	45	7- 0	12	60- 8	96	129- 7	165	84-10	98	....	
1912	253-11	453	0-14	3	2- 6	7	4- 2	11	19- 7	47	25- 3	54	72- 2	130	13- 7	24	63- 1	103	35- 3	51	17-14	23	....	
1913	111- 6	227	0- 0	0	0- 8	2	5-14	18	7-10	20	21- 2	49	28-11	58	31- 9	56	7-11	12	6- 3	9	2- 2	3	....	
1914	379-12	849	1- 4	6	8-10	30	27- 0	78	75- 1	192	117-14	267	90-12	178	44-15	77	10-11	16	3- 9	5	0- 0	0	....	
1915	176- 2	279	0- 0	0	0- 0	0	0- 5	1	2- 2	5	8- 5	18	19- 8	38	40- 6	69	43- 6	66	34-13	48	27- 5	34	....	
Average	**276.9**	**507**	**0.4**	**2**	**2.3**	**8**	**7.5**	**22**	**21.0**	**53**	**36.0**	**81**	**47.0**	**90**	**27.5**	**48**	**37.1**	**59**	**41.8**	**56**	**26.4**	**32**	....	
Standard grade—																								
1910	5- 5	14																						
1911	25- 2	46	0- 0	0	0-10	2	0- 0	0	2- 0	5	3- 6	7	8- 6	15	1-12	3	9- 0	14	0- 0	0	0- 0	0	....	
1912	13- 5	30	0-11	3	0- 5	1	1- 1	3	2- 0	5	4- 4	9	2- 0	4	2- 6	4	0-10	1	0- 0	0	0- 0	0	....	
1913	37- 6	86	0-11	3	2- 8	9	3- 6	10	3- 1	8	7-11	18	8- 0	17	6-15	13	2- 5	4	2- 1	3	0-12	1	....	
1914	26- 8	70	2- 8	13	1- 7	5	5- 0	14	2- 5	6	6- 7	15	6- 8	13	1-11	3	0-10	1	0- 0	0	0- 0	0	....	
1915	54-14	90	0- 0	0	0- 9	2	0-11	2	0- 6	1	3-14	9	8- 6	17	6-13	12	5- 3	8	17-14	25	11- 2	14	....	
Average	**27.1**	**56**	**0.8**	**4**	**1.1**	**4**	**2.0**	**6**	**2.0**	**5**	**5.1**	**12**	**6.7**	**13**	**3.9**	**7**	**3.8**	**6**	**4.0**	**6**	**2.4**	**3**	....	
Cull fruits—																								
1910	0- 0	0																						
1911	17- 5	27																						
1912	22-10	61																						
1913	50- 7	162																						
1914	4- 5	13																						
1915	17-12	38																						
Average	**18.7**	**50**																						
Total crop—																								
1910	432- 0	816	3- 0	12	7-10	23	17-14	48	51-12	123	58- 7	122	103- 2	192	29-13	51	102-14	161	33- 8	53	24- 0	31	....	
1911	356- 5	507	0- 0	0	0-10	2	0- 0	0	2-14	7	10-13	23	32- 6	60	8-12	15	69- 8	110	129- 7	165	84-10	98	....	
1912	289-10	544	1- 9	6	2-11	8	5- 3	14	21- 7	52	29- 7	63	74- 2	134	15-13	28	63-11	104	35- 3	51	17-14	23	2	
1913	199- 3	475	0-11	3	3- 0	11	9- 4	28	10-11	28	28-13	67	36-11	75	38- 8	69	10- 0	16	8- 4	12	2-14	4	1	
1914	410- 9	932	3-12	19	10- 1	35	32- 0	92	77- 6	198	124- 5	282	97- 4	191	46-10	80	11- 5	17	3- 9	5	0- 0	0	10	
1915	248-12	407	0- 0	0	0- 9	2	1- 0	3	2- 8	6	12- 3	27	27-14	55	47- 3	81	48- 9	74	52-11	73	38- 7	48	6	
Average	**322.7**	**613**	**1.5**	**7**	**4.1**	**14**	**10.9**	**31**	**27.8**	**69**	**44.0**	**97**	**61.9**	**118**	**31.1**	**54**	**51.0**	**80**	**43.8**	**59**	**27.9**	**34**	**5**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
10. Washington strain:																							
Orchard grade—																							
1910	218–2	473																					
1911	366–10	608	0–9	2	2–11	8	3–0	8	14–3	33	24–4	50	78–9	145	22–0	38	92–9	149	79–14	115	48–15	60	
1912	308–11	690	5–10	21	12–11	40	18–2	54	67–7	170	62–4	138	84–0	169	12–6	23	31–11	55	6–8	10	8–0	10	
1913	165–1	338	0–12	3	6–1	19	11–5	33	12–8	32	36–15	81	41–3	79	32–9	56	14–2	22	5–0	7	4–10	6	
1914	287–3	640	1–12	7	6–2	21	27–15	81	57–3	143	98–0	218	50–3	96	27–12	48	7–4	11	9–8	13	1–8	2	
1915	236–1	421	0–0	0	0–5	1	4–3	13	9–1	24	25–14	59	39–14	80	71–12	122	26–12	42	32–0	46	26–4	34	
Average	**263.6**	**528**	**1.7**	**7**	**5.6**	**18**	**12.9**	**38**	**32.1**	**80**	**49.5**	**109**	**58.8**	**114**	**33.3**	**57**	**16.5**	**56**	**26.6**	**38**	**17.9**	**22**	
Standard grade—																							
1910	16–0	40																					
1911	21–6	42	0–0	0	1–1	3	1–2	3	2–1	5	3–4	7	5–3	10	1–3	2	7–8	12	0–0	0	0–0	0	
1912	30–4	81	3–11	15	5–6	17	6–4	17	3–9	9	6–2	13	4–2	8	0–0	0	1–2	2	0–0	0	0–0	0	
1913	43–5	104	2–2	9	5–6	17	6–8	18	4–0	10	8–9	19	8–10	17	6–2	11	0–10	1	1–6	2	0–0	0	
1914	42–14	123	5–3	26	8–0	25	13–1	36	5–6	13	5–0	11	4–6	9	0–9	1	0–10	1	0–11	1	0–0	0	
1915	39–8	83	0–8	2	0–13	3	1–5	4	2.6	6	4–0	10	14–6	30	6–8	12	3–0	6	5–12	9	0–14	1	
Average	**32.2**	**79**	**2.3**	**10**	**4.1**	**13**	**5.7**	**16**	**3.5**	**9**	**5.4**	**12**	**7.3**	**15**	**2.9**	**5**	**2.6**	**4**	**1.6**	**2**	**0.2**	**0.2**	
Cull fruits—																							
1910	0–0	0																					
1911	8–7	16																					
1912	27–12	86																					
1913	24–8	64																					
1914	15–12	73																					
1915	15–12	40																					
Average	**15.4**	**47**																					

Total crop—																								
1910	234- 2	513	3- 0	13	4- 0	15	9- 0	29	17-11	49	40- 2	105	45- 9	103	39- 2	74	35-15	63	28-13	46	10-14	16	....	
1911	396- 7	666	0- 9	2	3-12	11	4- 2	11	16- 4	38	27- 8	57	83-12	155	23- 3	40	100- 1	161	79-14	115	48-15	60	....	
1912	366-11	857	9- 5	36	18- 1	57	24- 6	71	71- 0	179	68- 6	151	88- 2	177	12- 6	23	32-13	57	6- 8	10	8- 0	10	8	
1913	232-14	506	2-14	12	11- 7	36	17-13	51	16- 8	42	45- 8	100	49-13	96	38-11	67	14-12	23	6- 6	9	4-10	6	2	
1914	345-13	836	6-15	33	14- 2	46	41- 0	117	62- 9	156	103- 0	229	54- 9	105	28- 5	49	7-14	12	10- 3	14	1- 8	2	9	
1915	291- 5	544	0- 8	2	1- 2	4	5- 8	17	11- 7	30	29-14	69	54- 4	110	78- 4	134	29-12	48	37-12	55	27- 2	35	3	
Average	**311.2**	**654**	**4.0**	**16**	**8.7**	**28**	**16.9**	**49**	**32.5**	**82**	**52.4**	**118**	**62.7**	**124**	**36.7**	**65**	**36.8**	**61**	**28.2**	**42**	**6.9**	**22**	6	
1. Washington strain:																								
Orchard grade—																								
1910	191- 4	438																					....	
1911	301-11	488	0- 3	1	0- 5	1	3- 8	9	14-13	33	26-10	53	70- 5	125	10- 8	18	65- 5	102	59- 0	83	51- 2	63	....	
1912	357- 7	738	2- 7	9	11-11	36	18- 4	51	56- 3	139	54- 2	118	99-14	197	18- 3	33	63- 2	106	27- 9	41	6- 0	8	....	
1913	151- 0	283	0- 8	2	0-14	3	10- 1	27	10-14	26	21-12	47	30- 5	58	38- 3	65	15-10	24	14- 2	20	8-11	11	....	
1914	233- 3	455	0- 8	2	1-14	6	7- 2	20	21-12	53	71- 9	151	70-11	130	42- 7	69	11-12	17	3-14	5	1-10	2	....	
1915	243-11	460	0- 0	0	0- 5	1	2- 6	7	14- 3	36	36-14	85	62- 6	124	65- 6	114	34-13	55	15- 0	22	12- 6	16	....	
Average	**246.4**	**477**	**0.7**	**3**	**3.0**	**9**	**8.3**	**23**	**23.6**	**57**	**42.2**	**91**	**66.7**	**127**	**34.9**	**60**	**38.1**	**61**	**23.9**	**34**	**16.0**	**20**	....	
Standard grade—																								
1910	16-12	40																					....	
1911	18-12	38	0- 9	3	0-10	2	0-11	2	2- 4	5	2-14	6	7- 3	13	0-11	1	3-14	6	0- 0	0	0- 0	0	....	
1912	31-13	81	4- 0	17	1-13	6	4-13	13	8-14	21	4- 3	9	5- 3	10	0- 9	1	2- 6	4	0- 0	0	0- 0	0	....	
1913	29-11	65	0-12	3	1- 8	5	3-14	11	4- 2	10	4- 8	10	9- 2	17	3- 0	5	0-10	1	0-11	1	1- 8	2	....	
1914	31- 4	79	3- 6	17	0-15	3	6-12	18	2-15	7	7-12	17	4-11	9	3- 9	6	1- 4	2	0- 0	0	0- 0	0	....	
1915	75- 1	161	0- 3	1	0- 9	2	8-12	25	5- 8	14	15- 3	35	26- 1	53	9- 4	16	6-12	11	2- 1	3	0-12	1	....	
Average	**33.9**	**77**	**1.8**	**8**	**1.1**	**4**	**5.0**	**14**	**4.7**	**11**	**6.9**	**15**	**10.5**	**20**	**3.4**	**6**	**3.0**	**5**	**0.6**	**1**	**0.5**	**1**	....	
Cull fruits—																								
1910	0- 0	0																					....	
1911	14-12	28																					....	
1912	15- 5	59																					....	
1913	35-11	77																					....	
1914	21-12	65																					....	
1915	23- 8	65																					....	
Average	**18.5**	**49**																					....	
Total crop—																								
1910	208- 0	478	3- 7	14	7-11	27	14- 5	44	29- 0	78	50-10	120	39-15	83	34- 8	65	19- 9	33	7-11	12	1- 4	2	0	
1911	335- 3	554	0-12	4	0-15	3	4- 3	11	17- 1	38	29- 8	59	77- 8	138	11- 3	19	69- 3	108	59- 0	83	51- 2	63	....	
1912	404- 9	878	6- 7	26	13- 8	42	23- 1	64	65- 1	160	58- 5	127	105- 1	207	18-12	34	65- 8	110	27- 9	41	6- 0	8	1	
1913	216- 6	425	1- 4	5	2- 6	8	13-15	38	15- 0	36	26- 4	57	39- 7	75	41- 3	70	16- 4	25	14-13	21	10- 3	13	1	
1914	286- 3	599	3-14	19	2-13	9	13-14	38	24-11	60	79- 5	168	75- 6	139	46- 0	75	13- 0	19	3-14	5	1-10	2	10	
1915	342- 4	686	0- 3	1	0-14	3	11- 2	32	19-11	50	52- 1	120	88- 7	177	74-10	130	41- 9	66	17- 1	25	13- 2	17	0	
Average	**298.8**	**603**	**2.8**	**12**	**4.7**	**15**	**13.4**	**39**	**28.4**	**70**	**49.3**	**108**	**70.9**	**136**	**37.7**	**65**	**37.5**	**60**	**21.7**	**31**	**13.9**	**18**	3	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Total.		Sizes. 288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
14. Washington strain:																							
Orchard grade—																							
1910	170–8	450																					
1911	288–15	547	1–4	5	1–4	4	2–8	7	20–3	50	27–2	60	88–8	177	15–1	28	84–14	145	44–15	67	3–4	4	....
1912	226–9	579	12–9	50	25–5	84	19–10	59	54–0	145	43–4	103	41–8	94	7–9	13	13–14	25	5–14	6	0–0	0	....
1913	220–6	656	25–6	109	40–14	142	70–4	209	36–6	95	24–11	57	13–12	28	7–12	14	1–5	2	0–0	0	0–0	0	....
1914	283–14	721	4–12	19	24–4	85	48–0	144	57–12	153	80–6	188	47–10	96	17–3	30	3–4	5	0–11	1	0–0	0	....
1915	264–15	678	0–11	3	10–6	39	38–6	121	48–8	136	77–14	193	49–8	110	32–12	64	6–4	11	0–10	1	0–0	0	....
Average	**242.5**	**605**	**8.9**	**37**	**20.1**	**70**	**35.8**	**108**	**43.4**	**116**	**50.7**	**120**	**48.8**	**101**	**16.1**	**30**	**21.9**	**38**	**10.4**	**15**	**0.7**	**0.8**	....
Standard grade—																							
1910	15–0	46																					
1911	20–5	45	0–6	2	0–0	0	1–14	5	4–8	11	5–1	11	6–2	12	0–10	1	1–12	3	0–0	0	0–0	0	....
1912	40–7	120	8–3	34	5–15	20	6–12	20	9–6	24	5–6	13	2–8	5	1–11	3	0–10	1	0–0	0	0–0	0	....
1913	10–7	37	3–7	17	3–6	11	1–11	5	0–7	1	0–15	2	0–9	1	0–0	0	0–0	0	0–0	0	0–0	0	....
1914	28–4	84	3–4	16	3–8	12	8–4	24	2–10	7	4–14	11	2–15	6	2–13	5	0–0	0	0–0	0	0–0	0	....
1915	41–3	123	3–2	15	4–5	16	9–14	32	7–8	21	8–14	23	6–4	14	0–8	1	0–0	0	0–0	0	0–12	1	....
Average	**25.9**	**75**	**3.7**	**17**	**3.4**	**12**	**5.7**	**17**	**4.9**	**13**	**5.0**	**12**	**3.7**	**7**	**1.1**	**2**	**0.5**	**1**	**0**	**0**	**0.2**	**0.2**	....
Cull fruits—																							
1910	0–0	0																					
1911	9–2	18																					
1912	31–8	129																					
1913	38–3	139																					
1914	4–0	23																					
1915	38–2	120																					
Average	**20.6**	**72**																					

Total crop—																						
1910	185- 8	496	15- 2	60	27- 1	83	36- 2	113	46- 2	117	31- 9	68	20-15	41	4- 4	7	3- 9	6	0-12	1	0- 0	0	....
1911	318- 6	616	1-10	7	1- 4	4	4- 6	12	24-11	61	32- 3	71	94-10	189	15-11	29	86-10	148	44-15	67	3- 4	4	....
1912	301- 8	828	20-12	84	31- 4	104	26- 6	79	63- 6	169	48-10	116	47- 0	99	9- 4	16	14- 8	26	5-14	6	0- 0	0	2
1913	269- 0	832	28-13	126	44- 4	153	71-15	214	36-13	96	25-10	59	14- 5	29	7-12	14	1- 5	2	0- 0	0	0- 0	0	0
1914	316- 2	825	8- 0	35	27-12	97	56- 4	168	60- 6	160	85- 4	199	50- 9	102	20- 0	35	3- 4	5	0-11	1	0- 0	0	6
1915	344- 4	921	3-13	18	14-11	55	48- 4	153	56- 0	157	86-12	216	55-12	124	33- 4	65	6- 4	11	0-10	1	0-12	1	6
Average	**289.1**	**752**	**13.0**	**55**	**24.4**	**83**	**40.6**	**123**	**47.9**	**126**	**51.7**	**121**	**47.2**	**97**	**15.0**	**28**	**19.2**	**33**	**8.8**	**13**	**0.7**	**1**	**4**
19. Washington strain:																							
Orchard grade—																							
1910	275- 7	541																					
1911	244- 7	367	0- 0	0	0-10	2	0- 0	0	3-12	9	6-10	14	30- 2	58	7-11	13	62- 5	98	69- 8	98	63-13	75	....
1912	214- 6	386	0- 0	0	2-10	8	4- 6	12	12- 6	30	16-14	37	48-13	95	20- 1	36	46- 9	77	45-15	69	16-12	22	....
1913	80- 8	229	2-11	13	6- 4	24	16- 8	56	11-10	35	20- 4	53	14- 9	32	6- 3	12	1-13	3	0-10	1	0- 0	0	....
1914	359- 0	656	0- 4	1	1- 2	4	9- 6	25	18-12	47	76- 3	163	88- 6	164	94- 8	154	38-10	57	19- 2	26	12-11	15	....
1915	232-13	455	0- 0	0	0- 4	1	6-12	20	15- 8	40	40- 3	92	51- 7	106	68-10	122	27- 7	43	17-14	26	4-12	6	....
Average	**234.4**	**439**	**0.6**	**3**	**2.2**	**8**	**7.4**	**23**	**12.4**	**32**	**32.0**	**72**	**46.7**	**91**	**35.8**	**67**	**35.4**	**56**	**30.6**	**44**	**19.6**	**24**	....
Standard grade—																							
1910	8- 2	19																					
1911	14-12	27	0- 0	0	0- 5	1	1- 2	3	0-14	2	2- 7	5	3-14	7	0- 0	0	3- 6	5	2-12	4	0- 0	0	....
1912	12- 5	30	1- 2	4	1-11	5	1-13	5	1-10	4	2-10	6	0- 8	1	0- 9	1	2- 6	4	0- 0	0	0- 0	0	....
1913	87-12	266	7- 0	35	10- 3	40	17- 0	58	7-14	24	16-15	45	21- 0	48	5- 2	11	2-10	5	0- 0	0	0- 0	0	....
1914	34- 5	71	0- 3	1	0- 0	0	3- 3	9	2- 0	5	9-15	22	10- 2	20	4-12	8	2-10	4	0-11	1	0-13	1	....
1915	32-10	66	0- 3	1	1- 1	4	2- 2	6	0-12	2	5- 1	12	8- 3	17	5- 0	9	3-10	6	5- 2	7	1- 8	2	....
Average	**31.6**	**80**	**1.7**	**8**	**2.7**	**10**	**5.1**	**16**	**2.6**	**7**	**7.4**	**18**	**8.7**	**19**	**3.1**	**6**	**2.9**	**5**	**1.7**	**2**	**0.5**	**0.6**	....
Cull fruits—																							
1910	0- 0	0																					
1911	14-10	25																					
1912	6- 3	19																					
1913	49-12	184																					
1914	9-12	26																					
1915	6- 4	19																					
Average	**14.4**	**45**																					
Total crop—																							
1910	283- 9	560	3- 1	13	10- 0	32	9- 5	27	37-10	90	43-12	94	76-12	143	24-13	43	48- 2	77	30- 2	41	0- 0	0	....
1911	273-13	419	0- 0	0	0-15	3	1- 2	3	4-10	11	9- 1	19	34- 0	65	7-11	13	65-11	103	72- 4	102	63-13	75	....
1912	232-14	435	1- 2	4	4- 5	13	6- 3	17	14- 0	34	19- 8	43	49- 5	96	20-10	37	48-15	81	45-15	69	16- 2	22	2
1913	218- 0	679	9-11	48	16- 7	64	33- 8	114	19- 8	59	37- 3	98	35- 9	80	11- 5	23	4- 7	8	0-10	1	0- 0	0	1
1914	402-17	753	0- 7	2	1- 2	4	12- 9	34	20-12	52	86- 2	185	98- 8	184	99- 4	162	41- 4	61	19-13	27	13- 8	16	11
1915	271-11	540	0- 3	1	1- 5	5	8-14	26	16- 4	42	45- 4	104	59-10	122	73-10	131	31- 1	49	23- 0	33	6- 4	8	5
Average	**280.5**	**564**	**2.4**	**11**	**5.7**	**20**	**11.9**	**37**	**18.8**	**48**	**40.2**	**91**	**58.9**	**115**	**39.5**	**68**	**39.9**	**63**	**32.0**	**46**	**16.7**	**20**	**5**

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
26. Washington strain:																							
Orchard grade—																							
1910	224- 4	481																					
1911	309-14	496	0-10	3	0-10	2	1-10	4	10-12	26	16-13	35	36-12	70	14- 7	25	71-12	117	96- 8	140	60- 0	74	....
1912	262 11	561	2-12	11	4- 1	13	8- 7	24	35- 5	92	43-12	102	79 14	165	16- 8	32	51- 5	90	14- 7	23	6- 4	9	....
1913	134 12	280	1-10	6	3 14	12	12- 3	35	14- 6	28	32-13	72	24 13	57	31- 6	53	5-15	9	2 11	4	3- 1	4	....
1914	228- 8	502	0-10	3	5- 2	17	26- 8	72	38- 2	97	74- 6	162	47-14	91	31-10	54	2- 0	3	2- 4	3	0- 0	0	....
1915	202- 1	395	0- 0	0	1- 2	4	4-11	14	9- 7	25	32-14	78	38- 6	80	50-13	93	36- 6	60	22- 6	33	6- 0	8	....
Average	**227.0**	**453**	**1.1**	**5**	**3.0**	**10**	**10.7**	**30**	**21.0**	**54**	**40.1**	**90**	**46.5**	**93**	**29.0**	**51**	**33.5**	**56**	**27.7**	**41**	**15.1**	**19**	....
Standard grade—																							
1910	6-13	17																					
1911	21- 5	45	0- 9	3	0-15	3	0-12	2	3- 6	8	3- 7	7	5-14	11	2-12	5	3-10	6	0- 0	0	0- 0	0	....
1912	36- 1	96	3- 0	13	5- 1	16	3- 1	9	10- 3	26	6- 9	15	6-13	14	0- 0	0	1- 6	3	0- 0	0	0- 0	0	....
1913	21- 0	49	1- 8	6	0- 9	2	4-10	13	0-13	2	3- 1	7	6- 3	12	2- 4	4	2- 0	3	0- 0	0	0- 0	0	....
1914	26- 3	67	1- 8	8	0-15	3	7- 3	20	5-14	14	3-15	9	4- 0	8	2- 2	4	0- 0	0	0-10	1	0- 0	0	....
1915	37 10	82	0-11	4	1- 0	3	3- 6	10	2- 2	6	6- 5	15	10 0	21	4- 8	8	7- 8	12	0-10	1	1- 8	2	....
Average	**24.8**	**59**	**1.5**	**7**	**1.7**	**5**	**3.8**	**11**	**4.5**	**11**	**4.7**	**11**	**6.6**	**13**	**2.3**	**4**	**2.9**	**5**	**0.3**	**0.4**	**0.3**	**0.4**	....
Cull fruits—																							
1910	0- 0	0																					
1911	10- 0	18																					
1912	14- 0	61																					
1913	41-13	113																					
1914	7-10	33																					
1915	29- 4	68																					
Average	**17.1**	**49**																					

Total crop—																								
1910	231–1	498	3–13	16	14–7	45	13–0	37	46–9	114	38–15	85	55–12	106	21–0	36	27–2	44	9–9	14	0–14	1	....	
1911	341–3	559	1–3	6	1–9	5	2–6	6	14–2	34	20–4	42	42–10	81	17–3	30	75–6	123	96–8	140	60–0	74	....	
1912	312–12	718	5–12	24	9–2	29	11–8	33	45–8	118	50–5	117	86–11	179	16–8	32	52–11	93	14–7	23	6–4	9	5	
1913	197–9	442	3–2	12	4–7	14	16–13	48	12–3	30	35–14	79	36–0	69	33–10	57	7–15	12	2–11	4	3–1	4	4	
1914	262–5	602	2–2	11	6–1	20	33–11	92	44–0	111	78–5	171	51–14	99	33–12	58	2–0	3	2–14	4	0–0	0	1	
1915	268–15	545	0–11	4	2–2	7	8–1	24	11–9	31	39–3	93	48–6	101	55–5	101	43–14	72	23–0	34	7–8	10	4	
Average	**269.0**	**561**	**2.8**	**12**	**6.3**	**20**	**14.2**	**40**	**29.0**	**73**	**43.8**	**98**	**53.6**	**106**	**29.6**	**52**	**34.8**	**58**	**24.8**	**37**	**12.9**	**16**	**4**	
31. Washington strain:																								
Orchard grade—																								
1910	170–0	381																						
1911	266–5	421	0–0	0	0–5	1	1–6	3	4–15	11	8–12	19	38–14	74	10–9	19	84–12	135	84–14	120	31–14	39	....	
1912	257–0	566	3–13	16	12–3	40	14–8	42	37–15	97	38–14	89	77–13	159	12–6	23	43–10	76	12–4	19	3–10	5	....	
1913	173–1	357	2–8	10	6–5	20	15–1	42	18–2	45	34–15	76	29–13	57	39–10	68	13–12	21	7–10	11	5–5	7	....	
1914	246–6	569	3–0	13	16–8	54	35–4	100	49–14	123	69–10	150	47–0	88	21–5	35	3–3	5	0–10	1	0–0	0	....	
1915	250–3	560	0–7	2	3–6	12	17–8	53	34–8	93	56–15	136	63–0	132	49–6	92	16–5	27	6–10	10	2–2	3	....	
Average	**227.2**	**476**	**2.0**	**8**	**7.7**	**25**	**16.7**	**48**	**29.1**	**74**	**41.8**	**94**	**51.3**	**102**	**26.7**	**47**	**32.3**	**53**	**22.4**	**32**	**8.6**	**11**	....	
Standard grade—																								
1910	14–14	41																						
1911	15–7	32	0–4	2	0–10	2	0–15	3	1–5	3	2–6	5	3–3	6	1–2	2	5–10	9	0–0	0	0–0	0	....	
1912	24–4	61	2–3	9	2–12	9	2–2	6	4–11	12	5–2	11	3–15	8	0–0	0	3–7	6	0–0	0	0–0	0	....	
1913	20–2	51	1–4	5	6–0	19	1–5	4	2–10	7	2–4	5	1–8	3	2–5	4	1–5	2	0–11	1	0–14	1	....	
1914	10–5	35	2–11	14	1–8	5	3–3	9	1–2	3	0–7	1	1–6	3	0–0	0	0–0	0	0–0	0	0–0	0	....	
1915	38–5	96	1–6	8	2–10	9	4–12	14	4–0	11	10–4	25	8–2	17	3–5	6	1–12	3	2–2	3	0–0	0	....	
Average	**20.5**	**53**	**1.6**	**8**	**2.7**	**9**	**2.5**	**7**	**2.8**	**7**	**4.1**	**9**	**3.6**	**7**	**1.4**	**2**	**2.4**	**4**	**0.6**	**1**	**0.2**	**0.2**	....	
Cull fruits—																								
1910	0–0	0																						
1911	7–4	13																						
1912	8–8	31																						
1913	34–2	94																						
1914	7–1	34																						
1915	24–9	65																						
Average	**13.6**	**39**																						
Total crop—																								
1910	184–14	422	5–15	24	13–8	43	18–5	51	35–10	87	37–9	82	48–12	94	7–4	12	17–4	28	0–11	1	0–0	0	....	
1911	289–0	466	0–4	2	0–15	3	2–5	6	6–4	14	11–2	24	42–1	80	11–11	21	90–6	144	84–14	120	31–14	39	....	
1912	289–12	658	6–0	25	14–15	49	16–10	48	42–10	109	44–0	100	81–12	167	12–6	23	47–1	82	12–4	19	3–10	5	3	
1913	227–5	502	3–12	15	12–5	39	16–6	46	20–12	52	37–3	81	31–5	60	41–15	72	15–1	23	8–5	12	6–3	8	0	
1914	263–12	638	5–11	27	18–0	59	38–7	109	51–0	126	70–1	151	48–6	91	21–5	35	3–3	5	0–10	1	0–0	0	2	
1915	313–1	721	1–13	10	6–0	21	22–4	67	38–8	104	67–3	161	71–2	149	52–11	98	18–1	30	8–12	13	2–2	3	3	
Average	**261.3**	**568**	**3.9**	**17**	**11.0**	**36**	**19.0**	**54**	**32.5**	**82**	**44.5**	**100**	**53.9**	**107**	**24.5**	**44**	**31.8**	**52**	**19.3**	**28**	**7.3**	**9**	**2**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
38. Washington strain:																							
Orchard grade—																							
1910	144- 9	320																					
1911	224- 4	369	0- 8	3	1- 4	4	1- 8	4	9- 4	22	13- 1	28	36-15	70	8-10	16	58-11	95	52- 0	75	42- 7	52	
1912	200- 1	461	4-15	19	12- 3	39	12-13	37	37- 8	97	33- 7	78	53-10	111	12-15	25	23-12	42	3-12	6	5- 2	7	
1913	221- 2	596	12 10	54	24- 4	86	47-15	142	47- 4	124	47-12	109	23 14	49	16-12	31	0-11	1	0- 0	0	0- 0	0	
1914	232- 0	505	0-10	3	4-14	16	21-14	63	34- 4	87	75- 6	168	48- 3	93	30- 4	51	13- 8	20	0-11	1	2- 6	3	
1915	213-10	459	0- 3	1	1- 6	5	12-10	39	23 14	64	45- 2	108	43- 1	91	48-12	91	20- 2	33	11-12	18	6-12	9	
Average	**205.9**	**452**	**3.8**	**16**	**8.8**	**30**	**19.4**	**57**	**30.4**	**79**	**43.0**	**98**	**41.1**	**83**	**23.5**	**43**	**23.4**	**38**	**13.6**	**20**	**11.3**	**14**	
Standard grade—																							
1910	9- 5	25																					
1911	17- 9	34	0- 4	1	0- 5	1	1- 3	3	2- 5	5	3-14	8	5-10	10	0- 0	0	4- 0	6	0- 0	0	0- 0	0	
1912	43-11	122	6-14	28	6-15	22	6- 2	18	9- 6	24	6- 9	15	5- 8	11	0-10	1	1-11	3	0- 0	0	0- 0	0	
1913	15- 3	49	3- 9	17	2-14	9	4- 2	12	1- 8	4	2-10	6	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1914	8- 7	26	2- 1	11	0- 9	2	0-12	2	0-13	2	2- 3	5	1- 8	3	0- 9	1	0- 0	0	0- 0	0	0- 0	0	
1915	38- 0	92	1-10	9	1- 6	5	2-14	9	2- 7	7	7- 6	18	13- 0	28	4- 4	8	3- 0	5	1- 4	2	0-13	1	
Average	**22.0**	**58**	**2.9**	**13**	**2.4**	**8**	**3.0**	**9**	**3.3**	**8**	**4.5**	**10**	**5.2**	**11**	**1.1**	**2**	**1.7**	**3**	**0.3**	**0.4**	**0.2**	**0.2**	
Cull fruits—																							
1910	0- 0	0																					
1911	6- 9	13																					
1912	44-13	140																					
1913	39- 6	133																					
1914	10- 9	40																					
1915	27- 0	68																					
Average	**21.4**	**66**																					

Total crop—																								
1910	153-14	345	3- 5	14	11-14	39	12- 8	36	28-11	71	25- 9	56	45- 8	86	9- 2	15	14-13	24	2- 0	3	0- 8	1	....	
1911	248- 6	416	0-12	4	1- 9	5	2-11	7	11- 9	27	16-15	36	42- 9	80	8-10	16	62-11	101	52- 0	75	42- 7	52	....	
1912	288- 9	723	11-13	47	19- 2	61	18-15	55	46-14	121	40- 0	93	59- 2	122	13- 9	26	25- 7	45	3-12	6	5- 2	7	2	
1913	275-11	778	16- 3	71	27- 2	95	52- 1	154	48-12	128	50- 6	115	24- 6	50	16-12	31	0-11	1	0- 0	0	0- 0	0	0	
1914	251- 0	571	2-11	14	5- 7	18	22-10	65	35- 1	89	77- 9	173	49-11	96	30-13	52	13- 8	20	0-11	1	2- 6	3	0	
1915	278-10	619	1-13	10	2-12	10	15- 8	48	26- 5	71	52- 8	126	56- 1	119	53- 0	99	23- 2	38	13- 0	20	7- 9	10	10	
Average	**249.3**	**575**	**6.1**	**27**	**11.3**	**38**	**20.7**	**61**	**32.9**	**85**	**43.8**	**100**	**46.2**	**92**	**22.0**	**40**	**23.4**	**38**	**11.9**	**17**	**9.6**	**12**	**3**	
49. Washington strain:																								
Orchard grade—																								
1910	180-10	404																						
1911	247- 6	389	0- 3	1	0- 0	0	0- 6	1	3- 5	8	8- 2	17	38- 0	71	15- 1	26	75- 6	121	56- 0	82	50-15	62	....	
1912	245-11	570	7- 1	27	15- 2	48	18- 5	53	47-14	123	44-10	102	68- 0	140	7- 6	14	26-11	47	4-15	8	5-11	8	....	
1913	209-14	396	1-13	7	2-13	9	10- 5	28	18- 2	44	30-15	67	38- 9	74	53- 0	89	32- 4	49	9- 5	13	12-12	16	....	
1914	204-14	544	5- 5	21	30-15	102	45- 8	130	54-14	143	50- 7	114	14- 8	28	3- 5	6	0- 0	0	0- 0	0	0- 0	0	....	
1915	136- 0	249	0- 0	0	0- 5	1	2- 0	6	5- 0	13	14-10	35	22- 2	46	32- 2	58	27- 2	44	22- 5	33	10- 6	13	....	
Average	**204.1**	**425**	**2.9**	**11**	**9.8**	**32**	**15.3**	**44**	**25.8**	**66**	**29.8**	**67**	**36.2**	**72**	**22.2**	**39**	**32.3**	**52**	**18.5**	**27**	**16.0**	**20**	....	
Standard grade—																								
1910	20-12	50																						
1911	9- 3	17	0- 4	1	0- 0	0	0-12	2	0-14	2	0- 0	0	2-14	5	0- 9	1	3-14	6	0- 0	0	0- 0	0	....	
1912	22- 2	63	3- 9	15	2- 3	7	4-13	14	4-11	12	3-13	9	1- 6	3	0- 8	1	1- 3	2	0- 0	0	0- 0	0	....	
1913	20- 5	50	0- 9	2	2- 8	8	5- 3	15	2-11	7	3- 2	7	3-10	7	0-10	1	0-11	1	1- 5	2	0- 0	0	....	
1914	13- 3	43	2-12	14	2-12	9	4-10	13	2- 9	6	0- 0	0	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1915	49- 0	105	0- 0	0	1-12	7	2- 8	8	2-15	8	9- 8	23	13- 3	28	8- 8	15	4-14	8	4-15	7	0-13	1	....	
Average	**22.4**	**55**	**1.4**	**6**	**1.8**	**6**	**3.6**	**10**	**2.8**	**7**	**3.3**	**8**	**4.3**	**9**	**2.0**	**4**	**2.1**	**3**	**1.3**	**2**	**0.2**	**0.2**	....	
Cull fruits—																								
1910	0- 0	0																						
1911	5- 2	7																						
1912	17-12	57																						
1913	36- 8	86																						
1914	5- 3	20																						
1915	18- 6	43																						
Average	**13.8**	**35**																						
Total crop—																								
1910	201- 6	454	6- 6	23	15- 7	48	19- 9	53	45- 6	110	36- 5	79	49-13	94	13- 3	23	13- 3	21	0-10	1	1- 8	2	....	
1911	261-11	413	0- 7	2	0- 0	0	1- 2	3	4- 3	10	8- 2	17	40-14	76	15-10	27	79- 4	127	56- 0	82	50-15	62	....	
1912	285- 9	690	10-10	42	17- 5	55	23- 2	67	52- 9	135	48- 7	111	69- 6	143	7-14	15	27-14	49	4-15	8	5-11	8	2	
1913	266-11	532	2- 6	9	5- 5	17	15- 8	43	20-13	51	34- 1	74	42- 3	81	53-10	90	32-15	50	10-10	15	12-12	16	0	
1914	223- 4	607	8- 1	35	33-11	111	50- 2	143	57- 7	149	50- 7	114	15- 0	29	3- 5	6	0- 0	0	0- 0	0	0- 0	0	2	
1915	203- 6	397	0- 0	0	2- 1	8	4- 8	14	7-15	21	24- 2	58	35- 5	74	40-10	73	32- 0	52	27- 4	40	11- 3	14	17	
Average	**240.3**	**515**	**4.6**	**17**	**12.3**	**40**	**19.0**	**54**	**31.4**	**80**	**33.6**	**76**	**42.1**	**83**	**22.4**	**39**	**30.9**	**50**	**16.5**	**24**	**13.7**	**17**	**5**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
58. Washington strain:																							
Orchard grade—																							
1910	255- 2	489																					
1911	218- 3	333	0- 0	0	0- 5	1	0-12	2	3- 5	8	10 12	23	23- 7	44	6- 2	11	62- 6	100	52 14	75	58- 4	69	
1912	173- 2	337	0- 9	2	3 11	12	5- 9	16	16- 8	42	16 1	37	43- 5	87	9 13	18	42- 7	72	26- 1	39	9- 2	12	
1913	51-11	134	0-13	4	0-11	3	6- 1	22	5-13	18	12-13	35	8- 1	19	9- 3	19	3 7	6	2- 8	4	2- 5	4	
1914	257- 9	509	0-14	4	2- 0	7	8- 7	24	21 10	54	64 14	144	63 13	123	59- 4	101	26- 8	39	5- 5	7	4 14	6	
1915	178- 5	306	0 0	0	0- 0	0	0 5	1	2 12	7	17- 8	39	24-11	49	55 15	98	31- 1	49	27-11	40	18- 6	23	
Average	**189.0**	**351**	**0.5**	**2**	**1.3**	**5**	**1.2**	**13**	**10.0**	**26**	**24.4**	**56**	**32.7**	**64**	**28.1**	**49**	**33.2**	**53**	**22.9**	**33**	**18.6**	**23**	
Standard grade—																							
1910	3- 2	7																					
1911	30-10	50	0- 0	0	0- 0	0	0- 6	1	1-10	4	1 14	4	4- 4	8	1- 0	2	14- 4	21	7- 4	10	0- 0	0	
1912	18- 2	42	2- 5	9	0 11	2	0 12	2	2 13	7	2 12	6	4 10	9	1- 2	2	3- 1	5	0 0	0	0- 0	0	
1913	53- 4	156	2-13	15	3- 8	16	6- 1	23	5- 6	17	8-15	26	13- 1	33	7- 2	15	3- 2	6	3- 4	5	0- 0	0	
1914	35- 3	77	0- 2	1	0- 0	0	5- 6	15	4- 2	10	7- 9	17	11 12	24	2- 4	4	3- 4	5	0 12	1	0- 0	0	
1915	26- 4	48	0- 0	0	0- 0	0	0 5	1	0 12	2	3- 0	7	8- 2	16	5 10	10	2- 8	4	2 12	4	3- 3	4	
Average	**27.8**	**63**	**1.1**	**5**	**0.8**	**4**	**2.6**	**8**	**2.9**	**8**	**4.8**	**12**	**8.4**	**18**	**3.4**	**7**	**5.2**	**8**	**2.8**	**4**	**0.6**	**0.8**	
Cull fruits—																							
1910	**0- 0**	**0**																					
1911	18-11	33																					
1912	6-10	16																					
1913	37-12	140																					
1914	6-14	17																					
1915	8 1	21																					
Average	**13.0**	**38**																					

Total crop—																								
1910	258–4	496	1–7	6	7–1	22	6–14	19	32–3	78	39–5	85	66–8	125	19–4	33	52–3	83	22–12	32	10–11	13	....	
1911	267–8	416	0–0	0	0–5	1	1–2	3	4–15	12	12–10	27	27–11	52	7–2	13	76–10	121	60–2	85	58–4	69	....	
1912	197–14	395	2–14	11	4–6	14	6–5	18	19–5	49	18–13	43	47–15	96	10–15	20	45–8	77	26–1	39	9–2	12	10	
1913	142–11	430	3–10	19	4–3	19	12–2	45	11–3	35	21–12	61	21–2	52	16–5	34	6–9	12	5–12	9	2–5	4	6	
1914	299–10	603	1–0	5	2–0	7	13–13	39	25–12	64	72–7	161	75–9	147	61–8	105	29–12	44	6–1	8	4–14	6	16	
1915	212–10	375	0–0	0	0–0	0	0–10	2	3–8	9	20–8	46	32–13	65	61–9	108	33–9	53	30–7	44	21–9	27	11	
Average	**229.8**	**452**	**1.5**	**7**	**3.0**	**11**	**6.8**	**21**	**16.1**	**41**	**30.9**	**70**	**45.3**	**89**	**29.5**	**52**	**40.7**	**65**	**25.2**	**36**	**17.8**	**22**	**11**	
67. Washington strain:																								
Orchard grade—																								
1910	161–11	339	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1911	256–4	394	0–12	4	0–5	1	1–8	4	7–9	17	17–6	35	40–12	73	9–2	16	56–0	87	64–8	91	58–6	66	....	
1912	245–4	499	1–6	5	10–14	34	10–0	28	26–2	66	34–13	78	70–2	138	13–10	25	44–15	77	30–4	44	3–2	4	....	
1913	121–14	246	1–8	6	3–1	10	9–5	25	12–12	31	26–14	57	25–13	49	24–0	41	9–12	15	7–2	10	1–11	2	....	
1914	174–7	358	1–4	5	3–12	12	12–10	34	29–2	70	60–15	127	35–4	63	23–14	37	5–2	7	2–8	3	0–0	0	....	
1915	144–5	267	0–4	1	0–0	0	3–1	9	8–13	23	21–10	48	23–14	48	45–4	79	18–13	29	12–14	18	9–12	12	....	
Average	**184.0**	**351**	**1.0**	**4**	**3.6**	**11**	**7.3**	**20**	**16.9**	**41**	**32.3**	**69**	**39.2**	**74**	**23.2**	**40**	**26.9**	**43**	**23.5**	**33**	**14.6**	**17**	....	
Standard grade—																								
1910	15–11	33	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1911	14–15	27	0–0	0	0–0	0	0–12	2	0–14	2	3–7	7	2–11	5	0–0	0	7–3	11	0–0	0	0–0	0	....	
1912	21–2	54	3–2	12	0–10	2	3–10	10	4–8	11	3–14	9	3–10	7	0–0	0	1–12	3	0–0	0	0–0	0	....	
1913	21–13	48	0–4	1	1–10	5	4–15	14	2–8	6	4–4	9	1–9	3	1–11	3	1–14	3	1–7	2	1–11	2	....	
1914	33–0	76	1–14	10	2–2	7	3–15	10	5–14	14	4–10	10	6–6	12	4–12	8	2–12	4	0–11	1	0–0	0	....	
1915	34–13	71	1–2	5	0–9	2	2–0	6	1–8	4	3–2	7	10–14	22	7–6	13	5–2	8	0–10	1	2–8	3	....	
Average	**23.6**	**52**	**1.3**	**6**	**1.0**	**3**	**3.1**	**8**	**3.1**	**7**	**3.9**	**8**	**5.0**	**10**	**2.8**	**5**	**3.7**	**6**	**0.6**	**1.0**	**0.8**	**1**	....	
Cull fruits—																								
1910	0–0	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1911	5–4	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1912	19–1	55	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1913	35–15	81	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1914	2–0	13	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1915	17–0	39	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Average	**13.2**	**33**	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Total crop—																								
1910	177–6	372	3–15	13	9–11	31	9–2	25	30–5	73	22–12	69	55–10	104	11–8	19	19–8	31	4–1	6	0–14	1	....	
1911	276–7	430	0–12	4	0–5	1	2–4	6	8–7	19	20–13	42	43–7	78	9–2	16	63–3	98	64–8	91	58–6	66	....	
1912	285–7	608	4–8	17	11–8	36	13–10	38	30–10	77	38–11	87	73–12	145	13–10	25	46–11	80	30–4	44	3–2	4	2	
1913	179–10	375	1–12	7	4–11	15	14–4	39	15–4	37	31–2	66	27–6	52	25–11	44	11–10	18	8–9	12	3–6	4	1	
1914	209–7	447	3–2	15	5–14	19	16–9	44	35–0	84	65–9	137	41–10	75	28–10	45	7–14	11	3–3	4	0–0	0	11	
1915	196–2	377	1–6	6	0–9	2	5–1	15	10–5	27	24–12	55	34–12	70	52–10	92	23–15	37	13–8	19	12–4	15	8	
Average	**220.7**	**435**	**2.6**	**10**	**5.4**	**17**	**10.1**	**28**	**21.6**	**53**	**35.6**	**76**	**46.1**	**88**	**23.6**	**40**	**28.9**	**46**	**20.7**	**29**	**13.0**	**15**	**6**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
78. Washington strain:																							
Orchard grade—																							
1910	133- 8	285																					
1911	176-13	290	0- 3	1	0-10	2	2- 6	6	10- 9	24	9 3	19	38- 2	69	7-14	12	49 10	79	31 10	45	26-10	33	....
1912	185- 1	418	5- 9	21	11-10	37	16- 3	45	32 12	82	29- 4	65	52- 9	105	6 11	12	24 3	42	6 4	9	0 0	0	....
1913	157 3	339	1- 4	5	9- 3	30	11 15	34	26 3	65	37- 4	82	30- 0	58	26 11	44	5 15	9	7- 4	10	1- 8	2	....
1914	209 7	458	1-10	7	4-10	16	18-10	52	38 14	96	67- 3	143	52- 0	100	19 0	33	5 4	8	2- 4	3	0 0	0	....
1915	167 14	337	0- 0	0	0 14	3	3-12	11	7 14	21	31 6	73	42- 8	90	46 12	86	17-11	29	10 1	15	7- 0	9	....
Average	**171.6**	**355**	**1.7**	**7**	**5.4**	**18**	**10.6**	**30**	**23.3**	**58**	**34.9**	**76**	**43.0**	**84**	**21.4**	**37**	**20.5**	**33**	**9.7**	**16**	**7.0**	**9**	....
Standard grade—																							
1910	18- 1	38																					
1911	11- 2	21	0- 4	1	0-10	2	1- 3	3	0-14	2	1 8	3	0- 8	1	0- 9	1	2- 1	3	3- 9	5	0 0	0	....
1912	24-13	75	6- 5	29	3-12	12	1- 5	4	4-14	12	4- 7	10	2- 8	5	0- 8	1	1- 2	2	0- 0	0	0- 0	0	....
1913	21- 9	58	3-11	15	5- 0	16	2- 9	7	0-14	2	3 8	8	0-15	2	2- 4	4	1- 4	2	0-11	1	0 13	1	....
1914	27-15	75	1 10	9	3-11	12	7- 6	20	4 15	12	4 6	10	5- 6	11	0- 9	1	0- 0	0	0 0	0	0 0	0	....
1915	55- 4	124	0 10	3	1- 3	4	4- 4	13	6 3	17	11- 0	26	18- 1	38	7- 4	13	2- 8	4	2 11	4	1- 8	2	....
Average	**26.5**	**65**	**2.5**	**11**	**2.9**	**9**	**3.3**	**9**	**3.6**	**9**	**5.0**	**11**	**5.5**	**11**	**2.2**	**4**	**1.4**	**2**	**1.4**	**2**	**0.5**	**0.6**	....
Cull fruits—																							
1910	0- 0	0																					....
1911	2 12	5																					....
1912	14- 1	45																					....
1913	22- 1	60																					....
1914	3- 7	13																					....
1915	26- 0	65																					....
Average	**11.4**	**31**																					....

Total crop—																						
1910	151–9	323	1–2	5	4–12	16	6–12	20	10–13	29	31–2	74	31–7	65	32–5	60	20–6	35	6–9	10	6–5	9	....
1911	190–11	316	0–7	2	1–4	4	3–9	9	11–7	26	10–11	22	38–10	70	8–7	13	51–11	82	35–3	50	26–10	33	....
1912	223–15	538	11–14	50	15–6	49	17–8	49	37–10	94	33–11	75	55–1	110	7–3	13	25–5	44	6–4	9	0–0	0	0
1913	200–13	457	4–15	20	14–3	46	14–8	41	27–1	67	40–12	90	30–15	60	28–15	48	7–3	11	7–15	11	2–5	3	0
1914	240–13	546	3–4	16	8–5	28	26–0	72	43–13	108	71–9	153	57–6	111	19–9	34	5–4	8	2–4	3	0–0	0	6
1915	249–2	526	0–10	3	2–1	7	8–0	24	14–1	38	42–6	99	60–9	128	54–0	99	20–3	33	12–12	19	8–8	11	14
Average	**209.5**	**451**	**3.7**	**16**	**7.6**	**25**	**12.7**	**36**	**24.1**	**60**	**38.4**	**86**	**45.7**	**91**	**25.1**	**44**	**21.7**	**36**	**11.8**	**17**	**7.3**	**9**	**5**
88. Washington strain:																							
Orchard grade—																							
1910	116–1	238																					
1911	178–3	295	0–0	0	0–15	3	1–14	5	5–8	13	17–6	37	31–8	59	9–2	16	38–6	62	44–2	63	29–6	37	....
1912	159–13	300	1–13	7	2–14	9	3–8	10	8–11	22	16–7	37	38–12	77	8–10	16	39–13	67	26–14	39	12–7	16	....
1913	143–15	326	3–14	15	4–4	15	24–6	69	19–9	50	35–8	78	25–0	48	18–10	32	6–7	10	5–9	8	0–12	1	....
1914	225–0	508	2–14	13	10–14	38	28–2	80	40–0	100	55–0	120	48–2	92	31–8	53	5–8	8	2–4	3	0–12	1	....
1915	168–2	349	0–0	0	2–1	7	12–0	36	18–4	48	34–2	79	31–0	63	32–1	58	18–2	29	13–6	20	7–2	9	....
Average	**165.2**	**336**	**1.7**	**7**	**4.2**	**14**	**14.0**	**40**	**18.4**	**47**	**31.7**	**70**	**34.8**	**68**	**20.0**	**35**	**21.7**	**35**	**18.4**	**27**	**10.1**	**13**	....
Standard grade—																							
1910	14–12	35																					
1911	13–9	27	0–5	1	0–5	1	0–6	2	0–14	2	3–14	8	2–3	4	2–6	4	3–4	5	0–0	0	0–0	0	....
1912	18–7	42	2–1	8	0–10	2	1–8	4	3–6	8	1–15	4	5–11	11	0–0	0	3–4	5	0–0	0	0–0	0	....
1913	21–2	63	4–4	20	4–7	15	2–7	7	1–4	3	4–10	10	3–7	7	0–0	0	0–0	0	0–11	1	0–0	0	....
1914	37–1	113	8–7	46	3–0	10	4–6	12	4–6	11	4–5	10	9–11	19	1–11	3	1–3	2	0–0	0	0–0	0	....
1915	41–12	99	2–0	10	2–4	8	4–6	13	2–2	6	7–0	17	10–12	23	5–8	10	3–10	6	2–10	4	1–8	2	....
Average	**24.5**	**63**	**3.4**	**17**	**2.1**	**7**	**2.6**	**8**	**2.4**	**6**	**4.4**	**10**	**6.0**	**13**	**1.9**	**3**	**2.3**	**4**	**0.7**	**1**	**0.3**	**0.4**	....
Cull fruits—																							
1910	0–0	0																					
1911	5–14	10																					
1912	10–2	33																					
1913	21–13	60																					
1914	8–0	45																					
1915	23–4	69																					
Average	**11.5**	**36**																					
Total crop—																							
1910	130–13	273	1–14	7	8–7	27	8–13	24	23–0	56	17–6	37	35–12	66	11–6	19	21–3	33	2–4	3	0–12	1	....
1911	197–10	332	0–5	1	1–4	4	2–4	7	6–6	15	21–4	45	33–11	63	11–8	20	41–10	67	44–2	63	29–6	37	....
1912	188–6	375	3–14	15	3–8	11	5–0	14	12–1	30	18–6	41	44–7	88	8–10	16	43–1	72	26–14	39	12–7	16	3
1913	186–14	449	8–2	35	8–11	30	26–13	76	20–13	53	40–2	88	28–7	55	18–10	32	6–7	10	6–4	9	0–12	1	0
1914	270–1	666	11–5	59	13–14	48	32–8	92	44–6	111	59–5	130	57–13	111	33–3	56	6–11	10	2–4	3	0–12	1	7
1915	233–2	517	2–0	10	4–5	15	16–6	49	20–6	54	41–2	96	41–12	86	37–9	68	21–12	35	16–0	24	8–10	11	1
Average	**201.2**	**435**	**4.6**	**21**	**6.7**	**23**	**15.3**	**44**	**21.2**	**53**	**32.9**	**73**	**40.3**	**78**	**20.1**	**35**	**23.5**	**38**	**16.3**	**23**	**8.8**	**11**	**3**

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
93. Washington strain:																							
Orchard grade—																							
1910	133- 0	270																					....
1911	215- 0	360	0-15	4	0-10	2	0-13	2	6- 6	15	15- 3	32	42- 6	79	12- 2	21	64- 4	103	50-12	75	21- 9	27	....
1912	206-15	439	2- 7	9	6- 6	20	11-10	33	26- 0	66	38-14	88	54- 4	109	13-13	26	35- 7	60	10- 7	17	7-11	11	....
1913	109-10	234	1- 5	5	6- 3	20	14-14	41	9-14	24	27- 3	58	22- 0	42	15- 3	26	5- 8	8	2-14	4	4-10	6	....
1914	165-13	323	0- 7	2	2- 3	7	6- 8	18	20- 3	47	43-15	92	49-10	91	29-12	48	7- 2	10	4- 6	6	1-11	2	....
1915	128- 7	224	0- 0	0	0- 0	0	0-12	2	2-10	7	7-15	18	23-12	48	35-14	64	24- 2	39	25- 4	36	8- 2	10	....
Average	**159.8**	**308**	**1.0**	**4**	**3.1**	**10**	**6.9**	**19**	**13.0**	**32**	**26.6**	**58**	**38.4**	**74**	**21.4**	**37**	**27.3**	**44**	**18.7**	**28**	**8.7**	**11**	....
Standard grade																							
1910	17- 2	42																					....
1911	9-12	21	0- 2	2	0- 0	0	1- 2	3	1-12	4	0-14	2	2- 3	4	0- 9	1	2- 7	4	0-11	1	0- 0	0	...
1912	18- 5	45	1- 6	8	1- 6	4	1-11	5	2- 6	6	2-12	6	2- 9	5	1- 2	2	5- 1	9	0- 0	0	0- 0	0	....
1913	16-14	40	1- 2	4	0-11	2	5- 1	14	2- 6	6	1-12	4	3- 2	6	0- 9	1	0- 0	0	2- 3	3	0- 0	0	....
1914	16- 4	42	1- 8	8	0-14	3	2-15	8	3- 6	8	3-12	8	2- 0	4	0- 9	1	1- 4	2	0- 0	0	0- 0	0	....
1915	27- 6	54	0- 3	1	0- 4	1	1- 4	4	0- 6	1	3- 4	8	8- 7	17	6- 6	11	3-12	6	2-12	4	0-12	1	....
Average	**17.6**	**41**	**0.9**	**5**	**0.6**	**2**	**2.4**	**7**	**2.1**	**5**	**2.5**	**6**	**3.7**	**7**	**1.8**	**3**	**2.5**	**4**	**1.1**	**2**	**0.2**	**0.2**	....
Cull fruits—																							
1910	0- 0	0																					
1911	2- 0	4																					
1912	15- 8	52																					
1913	30- 8	84																					
1914	3- 8	13																					
1915	11-14	26																					
Average	**10.6**	**30**																					

Total crop—																								
1910	150- 2	312	3- 6	15	4- 1	14	8-13	25	23- 4	57	22-11	49	43- 9	82	12- 6	21	21- 5	34	7-10	11	3- 1	4	....	
1911	226-12	385	1- 1	6	0-10	2	1-15	5	8- 2	19	16- 1	34	44- 9	83	12-11	22	66-11	107	51- 7	76	21- 9	27	....	
1912	240-12	537	3-13	17	7-12	24	13- 5	38	28- 6	72	41-10	94	56-13	114	14-15	28	40- 8	69	10- 7	17	7-11	11	0	
1913	157- 0	358	2- 7	9	6-14	22	19-15	55	12- 4	30	28-15	62	25- 2	48	15-12	27	5- 8	8	5- 1	7	4-10	6	1	
1914	185- 9	378	1-15	10	3- 1	10	9- 7	26	23- 9	55	47-11	100	51-10	95	30- 5	49	8- 6	12	4- 6	6	1-11	2	1	
1915	167-11	304	0- 3	1	0- 4	1	2- 0	6	3- 0	8	11- 3	26	32- 3	65	42- 4	75	27-14	45	28- 0	40	8-14	11	3	
Average	**188.0**	**379**	**2.1**	**10**	**3.8**	**12**	**9.2**	**26**	**16.4**	**40**	**28.0**	**61**	**42.3**	**81**	**21.4**	**37**	**28.4**	**46**	**17.8**	**26**	**7.9**	**10**	**1**	
97. Washington strain:																								
Orchard grade—																								
1910	355- 3	588	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1911	96-11	119	0- 0	0	0- 5	1	0- 0	0	0- 7	1	0- 0	0	3-11	7	1-12	3	8- 7	13	36- 1	47	46- 0	47	....	
1912	119- 7	238	1- 6	5	5- 9	17	4- 8	12	20-11	50	11- 3	24	33- 6	63	6- 4	11	18- 1	29	18- 7	27	0- 0	0	....	
1913	26- 0	49	0- 4	1	0- 5	1	1- 4	4	0-12	2	2-11	6	3- 0	6	6- 7	12	4- 1	7	3- 6	5	3-14	5	....	
1914	185- 1	364	0- 8	2	0-10	2	8- 2	23	17-12	44	49- 4	106	47-10	90	47- 1	77	10- 2	15	3- 2	4	0 14	1	....	
1915	100- 9	142	0- 0	0	0- 0	0	0- 0	0	0- 6	1	2- 0	4	7- 0	13	19- 3	32	12- 0	18	27- 3	37	32 13	37	....	
Average	**147.1**	**250**	**0.4**	**2**	**1.4**	**4**	**3.0**	**8**	**8.0**	**20**	**13.0**	**28**	**18.9**	**36**	**16.1**	**27**	**10.5**	**16**	**17.6**	**24**	**16.7**	**18**	....	
Standard grade—																								
1910	4- 5	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1911	3- 2	5	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	1- 2	2	0- 0	0	2- 0	3	0- 0	0	0- 0	0	....	
1912	13- 5	34	2-10	10	0-10	2	1-13	5	2- 8	6	0-14	2	3-12	7	0- 9	1	0- 9	1	0- 0	0	0- 0	0	....	
1913	44- 2	100	0-14	4	1- 8	5	4- 2	13	2-10	8	7- 0	17	8-10	19	10-14	21	3- 9	6	2-10	4	2- 5	3	....	
1914	44-10	99	0- 6	2	1-14	6	6- 0	17	5-11	14	8-12	20	12-12	25	7- 1	12	0-11	1	0-11	1	0-12	1	....	
1915	14-10	25	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0-14	2	5-13	11	1- 2	2	3- 3	5	2- 1	3	1- 9	2	....	
Average	**20.7**	**46**	**0.8**	**3**	**0.8**	**3**	**2.4**	**7**	**2.2**	**6**	**3.5**	**8**	**6.4**	**13**	**3.9**	**7**	**2.0**	**3**	**1.1**	**2**	**0.9**	**1**	....	
Cull fruits—																								
1910	0- 0	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1911	14- 6	21	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1912	4-14	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1913	22- 5	60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1914	2-10	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1915	9- 0	18	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Average	**8.9**	**20**	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Total crop—																								
1910	359- 8	598	1- 5	5	6-13	21	15- 9	41	48- 2	111	64- 5	85	77-15	144	32-10	55	82- 6	96	21-15	30	8- 8	10	....	
1911	114- 3	145	0- 0	0	0- 5	1	0- 0	0	0- 7	1	0- 0	0	4-13	9	1-12	3	10- 7	16	36- 1	47	46- 0	47	....	
1912	137-10	284	4- 0	15	6- 3	19	6- 5	17	23- 3	56	12- 1	26	37- 2	70	6-13	12	18-10	30	18- 7	27	0- 0	0	0	
1913	92- 7	209	1- 2	5	1-13	6	5- 6	17	3- 6	10	9-11	23	11-10	25	17- 5	33	7-10	13	6- 0	9	6- 3	8	0	
1914	232- 5	472	0-14	4	2- 8	8	14- 2	40	23- 7	58	58- 0	126	60- 6	115	54- 2	89	10-13	16	3-13	5	1-10	2	15	
1915	124- 3	185	0- 0	0	0- 0	0	0- 0	0	0- 6	1	2-14	6	12-13	24	20- 5	34	15- 3	23	29- 4	40	34- 6	39	0	
Average	**176.7**	**316**	**1.2**	**5**	**2.9**	**9**	**6.9**	**19**	**16.5**	**39**	**24.5**	**44**	**34.1**	**65**	**22.1**	**38**	**24.2**	**33**	**19.3**	**26**	**16.1**	**18**	**4**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
100. Washington strain:																							
Orchard grade—																							
1910	161- 2	357																					
1911	165- 4	348	1- 0	5	5- 1	16	6- 2	17	27- 0	66	28- 1	62	49-12	100	11- 3	21	20- 6	35	15- 2	24	1- 9	2	....
1912	184- 1	491	15- 4	58	27-10	88	29- 4	83	53- 4	135	31-14	73	20- 8	42	2- 6	5	3-15	7	0- 0	0	0- 0	0	....
1913	124-12	357	9-14	42	16-15	61	37-13	112	22- 9	59	23-10	55	8-10	18	5- 5	10	0- 0	0	0- 0	0	0- 0	0	....
1914	125- 1	289	0- 4	1	5- 7	18	15- 7	43	25- 2	63	46- 4	103	23- 0	45	6 15	12	2-10	4	0- 0	0	0- 0	0	....
1915	87- 3	195	0- 4	1	0-15	3	4- 4	13	10-14	29	26- 3	63	21- 2	44	14- 8	27	6- 7	11	2-10	4	0- 0	0	....
Average	**141.2**	**340**	**5.3**	**21**	**11.2**	**37**	**18.6**	**54**	**27.8**	**70**	**31.2**	**71**	**24.6**	**50**	**8.1**	**15**	**6.7**	**11**	**3.6**	**6**	**0.3**	**0.4**	....
Standard grade—																							
1910	6- 6	17																					
1911	12- 3	31	1- 0	5	1-14	6	1- 9	4	2- 8	6	1-14	4	1- 8	3	0- 0	0	1-14	3	0- 0	0	0- 0	0	....
1912	14- 0	44	2-11	12	2- 3	9	2- 1	6	3- 2	8	1-15	5	0-15	2	1- 1	2	0- 0	0	0- 0	0	0- 0	0	....
1913	30- 2	115	13- 6	65	6-15	24	5- 2	15	2- 6	6	1- 4	3	0- 8	1	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1914	29-10	84	4- 6	21	2-15	9	8- 7	23	5- 6	13	4-14	11	1-15	4	1-11	3	0- 0	0	0- 0	0	0- 0	0	....
1915	54- 0	114	0-10	3	0- 4	1	2- 4	7	1- 7	4	8- 2	20	15-15	35	9-14	19	4- 8	8	10- 4	16	0-12	1	....
Average	**24.4**	**68**	**4.4**	**21**	**2.8**	**10**	**3.9**	**11**	**3.0**	**7**	**3.6**	**9**	**4.2**	**9**	**2.6**	**5**	**1.3**	**2**	**2.1**	**3**	**0.2**	**0.2**	....
Cull fruits—																							
1910	0- 0	0																					
1911	3- 1	7																					
1912	4-11	19																					
1913	14- 8	52																					
1914	8- 8	42																					
1915	12- 8	26																					
Average	**7.2**	**24**																					

Total crop—																								
1910	167- 8	374	1- 0	4	2-12	11	7-10	24	16- 6	45	36-14	88	35- 9	77	41-12	81	11-14	21	9- 7	16	4- 4	7	....	
1911	180- 8	386	2- 0	10	6-15	22	7-11	21	29- 8	72	29-15	66	51- 4	103	11- 3	21	22- 4	38	15- 2	24	1- 9	2	....	
1912	202-12	554	17-15	70	29-13	97	31- 5	89	56- 6	143	33-13	78	21- 7	44	3- 7	7	3-15	7	0- 0	0	0- 0	0	4	
1913	169- 6	524	23-14	107	23-14	85	42-15	127	24-15	65	24-14	58	9- 2	19	5-14	11	0- 0	0	0- 0	0	0- 0	0	2	
1914	163- 3	415	4-10	22	8- 6	27	23-14	66	30- 8	76	51- 2	114	24-15	49	8-10	15	2-10	4	0- 0	0	0- 0	0	12	
1915	153-11	335	0-14	4	1- 3	4	6- 8	20	12- 5	33	34- 5	83	37- 1	79	24- 6	46	10-15	19	12-14	20	0-12	1	2	
Average	**172.8**	**431**	**8.3**	**36**	**12.1**	**41**	**20.0**	**58**	**28.3**	**72**	**35.2**	**81**	**29.9**	**62**	**15.9**	**30**	**8.6**	**15**	**6.2**	**10**	**1.1**	**2**	**5**	
103. Washington strain:																								
Orchard grade—																								
1910	106- 5	236	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1911	122- 2	270	1- 2	4	9- 2	29	10- 4	28	27- 8	63	23- 1	52	27-11	54	4-14	9	10- 8	18	8- 0	13	0- 0	0	....	
1912	168- 1	498	25-10	100	45-15	146	35- 3	100	46-11	120	9- 2	21	4- 5	9	0- 9	1	0-10	1	0- 0	0	0- 0	0	....	
1913	163- 7	508	19- 8	89	32- 8	119	45-10	140	28-10	76	25- 7	60	10- 3	21	1- 9	3	0- 0	0	0- 0	0	0- 0	0	....	
1914	131- 0	331	1- 3	5	8-12	29	33- 0	94	32- 8	82	41- 5	93	13- 2	26	1- 2	2	0- 0	0	0- 0	0	0- 0	0	....	
1915	101- 3	234	0- 0	0	1- 8	5	11- 0	33	16-12	44	28- 0	66	22-15	48	18- 1	33	2- 5	4	0-10	1	0- 0	0	....	
Average	**132.0**	**346**	**9.5**	**40**	**19.6**	**66**	**27.0**	**79**	**30.4**	**77**	**25.4**	**58**	**15.7**	**32**	**5.2**	**10**	**2.7**	**5**	**1.7**	**3**	**0**	**0**	....	
Standard grade—																								
1910	17- 6	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1911	25- 9	66	3- 4	13	3- 0	9	4-14	13	5- 9	13	6- 3	13	1- 8	3	0- 9	1	0-10	1	0- 0	0	0- 0	0	....	
1912	15-10	66	10- 2	51	2-11	8	0- 5	1	1- 4	3	1- 4	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1913	23- 9	86	8- 6	42	5- 0	18	3- 5	10	2-10	7	2- 3	5	2- 1	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	28-12	81	3- 5	16	4- 8	15	5-13	16	4- 1	10	7- 9	17	3- 0	6	0- 8	1	0- 0	0	0- 0	0	0- 0	0	....	
1915	22- 3	53	0-10	3	0-10	2	1-15	6	2- 8	7	1- 2	3	9-12	22	3-12	7	0- 9	1	0-10	1	0-11	1	....	
Average	**22.2**	**67**	**5.1**	**25**	**3.2**	**10**	**3.3**	**9**	**3.2**	**8**	**3.7**	**8**	**3.3**	**7**	**1.0**	**2**	**0.2**	**0.4**	**0.1**	**0.2**	**0.1**	**0.2**	....	
Cull fruits—																								
1910	0- 0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1911	7- 8	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1912	6-13	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1913	18- 9	77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1914	5- 0	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1915	4-10	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
Average	**7.1**	**29**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
Total crop—																								
1910	123-11	283	1- 0	4	3-13	13	8- 8	26	11-13	32	36-15	87	34- 0	71	18- 3	34	5-15	10	1-13	3	1-11	3	....	
1911	155- 3	355	4- 6	17	12- 2	38	15- 2	41	33- 1	76	29- 4	65	29- 3	57	5- 7	10	11- 2	19	8- 0	13	0- 0	0	....	
1912	190- 8	599	35-12	151	48-10	154	35- 8	101	47-15	123	10- 6	24	4- 5	9	0- 9	1	0-10	1	0- 0	0	0- 0	0	1	
1913	205- 9	671	27-14	131	37- 8	137	48-15	150	31- 4	83	27-10	65	12- 4	25	1- 9	3	0- 0	0	0- 0	0	0- 0	0	0	
1914	164-12	442	4- 8	21	13- 4	44	38-13	110	36- 9	92	48-14	110	16- 2	32	1-10	3	0- 0	0	0- 0	0	0- 0	0	7	
1915	128- 0	302	0-10	3	2- 2	7	12-15	39	19- 4	51	29- 2	69	32-11	70	21-13	40	2-14	5	1- 4	2	0-11	1	1	
Average	**161.3**	**442**	**12.3**	**54**	**19.6**	**66**	**26.6**	**78**	**30.0**	**76**	**30.4**	**70**	**21.4**	**44**	**8.2**	**15**	**3.5**	**6**	**1.8**	**3**	**0.4**	**1**	**2**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Total.		Sizes. 288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
107. Washington strain:																							
Orchard grade—																							
1910	96–14	210																					
1911	159– 0	314	0– 6	2	1–10	5	3– 8	10	14– 7	36	25– 7	57	52–11	103	18– 3	33	29– 4	48	13– 8	20	0– 0	0	....
1912	163– 8	436	11– 4	44	26– 0	83	21–14	62	52–14	135	30–10	70	18–10	38	1– 2	2	1– 2	2	0– 0	0	0– 0	0	....
1913	97– 6	284	9–14	43	16– 0	56	27–12	83	18– 2	46	18– 3	42	5– 9	11	1– 2	2	0– 0	0	0–12	1	0– 0	0	....
1914	92– 3	213	0– 8	2	2– 4	7	16– 6	45	27– 4	66	30– 2	65	13– 2	24	1–14	3	0–11	1	0– 0	0	0– 0	0	....
1915	105– 8	246	0– 0	0	3– 2	11	9–14	30	24–14	64	30–14	70	21–14	45	10– 9	19	4– 5	7	0– 0	0	0– 0	0	....
Average	**119.1**	**284**	**4.4**	**18**	**9.8**	**32**	**15.9**	**46**	**27.5**	**69**	**27.1**	**61**	**22.4**	**44**	**6.6**	**12**	**7.1**	**12**	**2.9**	**4**	**0**	**0**	....
Standard grade—																							
1910	10– 5	23																					
1911	16– 3	35	0–14	3	0–10	2	3– 5	9	2–11	6	2– 6	5	2– 4	4	0–11	1	1– 4	2	2– 2	3	0– 0	0	....
1912	19– 8	64	5–11	27	2–12	9	3– 9	10	4–14	12	2–10	6	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	32– 6	120	14– 4	67	7– 4	25	6– 8	19	0– 6	1	2– 5	5	1– 1	2	0– 0	0	0–10	1	0– 0	0	0– 0	0	....
1914	24– 5	70	4– 2	19	3– 4	10	6–10	18	5– 8	13	3– 5	7	1– 8	3	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1915	37– 1	91	1– 0	5	1–12	6	5–12	17	4–14	13	9– 2	22	7– 3	15	3–12	7	3– 0	5	0–10	1	0– 0	0	....
Average	**23.3**	**67**	**5.2**	**24**	**3.1**	**10**	**5.2**	**15**	**3.7**	**9**	**4.0**	**9**	**2.4**	**5**	**0.9**	**2**	**1.0**	**2**	**0.6**	**1**	**0**	**0**	....
Culls fruits—																							
1910	0– 0	0																					
1911	2– 0	5																					
1912	12– 0	60																					
1913	21– 0	94																					
1914	5–10	30																					
1915	3–14	11																					
Average	**7.4**	**33**																					

Total crop—																								
1910	107- 3	233	1-10	7	2-14	9	8- 3	24	14-14	38	22-14	47	19-12	40	17- 8	35	13-15	24	4-15	8	0-10	1	....	
1911	177- 3	354	1- 4	5	2- 4	7	6-13	19	17- 2	42	27-13	62	54-15	107	18-14	34	30- 8	50	15-10	23	0- 0	0	....	
1912	195- 0	560	16-15	71	28-12	92	25- 7	72	57-12	147	33- 4	76	18-10	38	1- 2	2	1- 2	2	0- 0	0	0- 0	0	3	
1913	150-12	498	24- 2	110	23- 4	81	34- 4	102	18- 8	47	20- 8	47	6-10	13	1- 2	2	0-10	1	0-12	1	0- 0	0	0	
1914	122- 2	313	4-10	21	5- 8	17	23- 0	63	32-12	79	33- 7	72	14-10	27	1-14	3	0-11	1	0- 0	0	0- 0	0	4	
1915	146- 7	348	1- 0	5	4-14	17	15-10	47	29-12	77	40- 0	92	29- 1	60	14- 5	26	7- 5	12	0-10	1	0- 0	0	1	
Average	**149.8**	**384**	**8.3**	**36**	**11.3**	**37**	**18.9**	**55**	**28.5**	**72**	**29.7**	**66**	**23.9**	**48**	**9.1**	**17**	**9.0**	**15**	**3.6**	**5**	**0.1**	**0**	**2**	
112. Washington strain:																								
Orchard grade—																								
1910	115- 0	246																						
1911	127- 2	255	0-10	2	3- 0	9	2-13	8	12-13	32	22-12	50	43- 4	84	8-12	16	24- 2	40	9- 0	14	0- 0	0	....	
1912	151- 0	415	13- 2	50	28- 8	90	29-12	84	40- 1	103	25-15	60	12- 6	26	0- 0	0	1- 4	2	0- 0	0	0- 0	0	....	
1913	98-12	277	7-14	34	11-11	42	25- 9	77	19- 3	50	19- 6	45	10- 5	21	3- 6	6	0- 0	0	1- 6	2	0- 0	0	....	
1914	114-14	282	1- 0	4	6- 1	20	29-14	83	28- 2	69	37- 4	82	10- 4	20	2- 5	4	0- 0	0	0- 0	0	0- 0	0	....	
1915	99- 5	214	0- 0	0	0- 9	2	3- 8	11	11- 8	31	25- 2	60	23- 0	48	24-12	45	7- 8	12	1-15	3	1- 7	2	....	
Average	**117.7**	**282**	**4.5**	**18**	**10.0**	**33**	**18.3**	**53**	**22.3**	**57**	**26.1**	**59**	**19.8**	**40**	**7.8**	**14**	**6.6**	**11**	**2.5**	**4**	**0.3**	**0.4**	....	
Standard grade—																								
1910	11- 1	27																						
1911	17- 2	44	1- 8	8	1-10	6	2-12	7	2- 2	5	5-14	12	2-10	5	0- 0	0	0-10	1	0- 0	0	0- 0	0	....	
1912	10- 5	35	2-14	15	1-14	6	1-10	5	1- 2	3	1- 5	3	0-15	2	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1913	21- 9	72	6- 0	26	7- 3	25	3- 7	10	0- 6	1	2- 8	6	1- 8	3	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1914	25-13	77	4- 8	22	3- 8	11	7- 4	20	5- 6	13	3- 2	7	1- 8	3	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1915	38- 2	84	0- 8	4	0- 0	0	1- 4	4	2- 2	6	3-10	9	16- 9	36	8- 0	15	2-15	5	2- 8	4	0-10	1	....	
Average	**20.7**	**57**	**3.1**	**15**	**2.8**	**10**	**3.3**	**9**	**2.2**	**6**	**3.4**	**7**	**4.6**	**10**	**1.9**	**4**	**0.7**	**1**	**0.5**	**1**	**0.1**	**0.2**	....	
Cull fruits—																								
1910	0- 0	0																						
1911	1-14	4																						
1912	5- 2	24																						
1913	9-10	45																						
1914	5-11	34																						
1915	6- 0	20																						
Average	**4.7**	**21**																						
Total crop—																								
1910	126- 1	273	0- 8	2	1- 4	4	6- 8	19	13-14	37	31- 4	72	31- 5	65	19- 8	37	12-11	22	4-13	8	4- 6	7	....	
1911	146- 2	299	2- 2	10	4-10	15	5- 9	15	14-15	37	28-10	62	45-14	89	8-12	16	24-12	41	9- 0	14	0- 0	0	....	
1912	166- 7	474	16- 0	65	30- 6	96	31- 6	89	41- 3	106	27- 4	63	13- 5	28	0- 9	1	1- 4	2	0- 0	0	0- 0	0	2	
1913	129-15	394	13-14	60	18-14	67	29- 0	87	19- 9	51	21-14	51	11-13	24	3-15	7	0- 0	0	1- 6	2	0- 0	0	0	
1914	146- 6	393	5- 8	26	9- 9	31	37- 2	103	33- 8	82	40- 6	89	11-12	23	2-14	5	0- 0	0	0- 0	0	0- 0	0	12	
1915	143- 7	318	0- 8	4	0- 9	2	4-12	15	13-10	37	28-12	69	39- 9	84	32-12	60	10- 7	17	4- 7	7	2- 1	3	1	
Average	**143.1**	**359**	**6.4**	**28**	**10.9**	**36**	**19.1**	**55**	**22.8**	**58**	**29.7**	**68**	**25.6**	**52**	**11.4**	**21**	**8.2**	**14**	**3.2**	**5**	**1.1**	**1**	**4**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
117. Washington strain:																							
Orchard grade—																							
1910	86- 8	194																					
1911	114- 5	259	2-14	11	7- 8	23	9-12	27	26- 6	65	18-11	42	31- 0	61	5- 0	9	10- 8	17	2-10	4	0- 0	0	
1912	134- 8	396	23- 2	93	25- 5	81	25- 5	74	37- 5	96	14- 4	33	8- 2	17	0- 0	0	1- 1	2	0- 0	0	0- 0	0	
1913	117- 6	403	29-15	144	21- 7	79	29 11	92	15- 9	42	13 1	31	5- 6	11	2- 5	4	0- 0	0	0- 0	0	0- 0	0	
1914	95- 0	238	2- 2	9	5- 8	18	20-14	60	20- 3	51	35- 9	79	8- 2	16	2-10	5	0- 0	0	0- 0	0	0- 0	0	
1915	84- 3	192	0- 2	2	0-14	3	9- 5	28	12-14	34	25- 0	58	16-10	34	10-14	20	3-12	6	3- 4	5	1- 8	2	
Average	**105.3**	**280**	**11.6**	**52**	**12.1**	**41**	**19.0**	**56**	**22.5**	**58**	**21.3**	**49**	**13.9**	**28**	**4.2**	**8**	**3.1**	**5**	**1.2**	**2**	**0.3**	**0.4**	
Standard grade—																							
1910	11- 0	28																					
1911	13- 3	31	0- 5	1	1-11	5	3- 2	8	2- 9	6	2- 6	5	3- 2	6	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1912	12- 4	57	8- 0	45	2-10	8	0-12	2	0- 0	0	0-14	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1913	20- 0	82	7-14	43	4- 6	17	4- 1	13	1-15	5	1- 4	3	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1914	23- 7	92	7- 0	46	4- 4	14	6-10	19	1- 8	4	2- 2	5	1-15	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1915	36- 8	98	0-14	6	3- 9	13	5- 6	17	3- 5	10	4-14	13	10- 8	24	4-10	9	2-12	5	0-10	1	0- 0	0	
Average	**19.4**	**65**	**4.8**	**28**	**3.3**	**11**	**4.0**	**12**	**1.9**	**5**	**2.3**	**6**	**1.4**	**7**	**0.9**	**2**	**0.6**	**1**	**0.1**	**0.2**	**0**	**0**	
Cull fruits—																							
1910	0- 0	0																					
1911	2 10	7																					
1912	3- 4	20																					
1913	12-14	60																					
1914	2- 6	14																					
1915	2- 8	12																					
Average	**3.9**	**19**																					

Total crop—																						
1910	97- 8	222	0-12	3	2- 8	9	5- 0	16	11- 8	31	27- 6	67	23- 2	47	22- 4	41	3-13	6	0- 9	1	0-10	1	....
1911	130- 2	297	3- 3	12	9- 3	28	12-14	35	28-15	71	21- 1	47	34- 2	67	5- 0	9	10- 8	17	2-10	4	0- 0	0	....
1912	150- 0	473	31- 2	138	27-15	89	26- 1	76	37- 5	96	15- 2	35	8- 2	17	0- 0	0	1- 1	2	0- 0	0	0- 0	0	4
1913	150- 4	545	37-13	187	25-13	96	33-12	105	17- 8	47	14- 5	34	5-14	12	2- 5	4	0- 0	0	0- 0	0	0- 0	0	9
1914	120-13	344	9- 2	55	9-12	32	27- 8	79	21-11	55	37-11	84	10- 1	20	2-10	5	0- 0	0	0- 0	0	0- 0	0	9
1915	123- 3	302	1- 0	8	4- 7	16	14-11	45	16- 3	44	29-14	71	27- 2	58	15- 8	29	6- 8	11	3-14	6	1- 8	2	3
Average	**128.6**	**364**	**13.8**	**67**	**13.3**	**45**	**20.0**	**59**	**22.2**	**57**	**24.2**	**56**	**18.1**	**37**	**7.9**	**15**	**3.7**	**6**	**1.2**	**2**	**0.3**	**1**	**4**
121. Washington strain:																						
Orchard grade—																						
1910	85- 0	203	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1911	139- 1	296	1- 4	5	4-12	15	6-11	19	21-1	53	17-11	40	42-15	86	11- 7	22	23- 4	40	10- 0	16	0- 0	0	....
1912	125- 9	366	20-12	87	21-10	70	20-12	60	29-0	75	19- 6	45	12- 7	26	0- 0	0	1- 0	2	0-10	1	0- 0	0	....
1913	84-14	280	19- 2	89	14- 7	53	23- 8	72	11-1	29	10-14	25	4- 5	9	1- 9	3	0- 0	0	0- 0	0	0- 0	0	....
1914	80- 3	185	0- 0	0	4- 0	13	13-10	38	16-4	40	25- 6	55	14- 7	28	5-14	10	0-10	1	0- 0	0	0- 0	0	....
1915	31-12	68	0- 0	0	0- 0	0	1-11	5	5-4	13	8- 6	19	7- 7	15	7-12	14	0-10	1	0-10	1	0- 0	0	....
Average	**91.1**	**233**	**8.2**	**36**	**9.0**	**30**	**13.3**	**39**	**16.5**	**42**	**16.3**	**37**	**16.3**	**33**	**5.3**	**10**	**5.1**	**9**	**2.3**	**4**	**0**	**0**	....
Standard grade—																						
1910	11-14	30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1911	14- 6	36	1- 5	6	2- 3	7	1- 3	3	4- 6	10	1- 5	3	1- 1	2	1-11	3	1- 4	2	0- 0	0	0- 0	0	....
1912	13- 9	54	6- 0	33	1-14	6	2- 1	6	2- 5	6	1- 5	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	29- 2	129	17- 6	93	5- 6	19	2-15	9	1- 2	3	0-14	2	1- 7	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	22-10	64	2-14	12	4-11	15	7-12	21	2- 0	5	4- 1	9	0- 0	0	0- 0	0	1- 4	2	0- 0	0	0- 0	0	....
1915	54-11	138	1- 2	5	2- 2	8	6-10	21	7-10	21	11-11	30	14-14	33	6-10	13	2-14	5	1- 2	2	0- 0	0	....
Average	**24.4**	**75**	**5.7**	**30**	**3.3**	**11**	**4.1**	**12**	**3.5**	**9**	**3.9**	**9**	**3.5**	**8**	**1.7**	**3**	**1.1**	**2**	**0.2**	**0.4**	**0**	**0**	....
Cull fruits—																						
1910	0- 0	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1911	0-12	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1912	7-15	35	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1913	10- 4	44	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1914	2- 4	14	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1915	2- 9	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Average	**4.0**	**17**	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Total crop—																						
1910	96-14	233	4- 0	16	3- 8	11	10- 4	30	17-12	47	34- 5	79	12- 4	25	8- 3	15	4-15	8	1-11	2	0- 0	0	....
1911	154- 3	334	2- 9	11	6-15	22	7-14	22	25- 7	63	19- 0	43	44- 0	88	13- 2	25	24- 8	42	10- 0	16	0- 0	0	....
1912	147- 1	455	26-12	120	23- 8	76	22-13	66	31- 5	81	20-11	48	12- 7	26	0- 0	0	1- 0	2	0-10	1	0- 0	0	3
1913	124- 4	453	36- 8	182	19-13	72	26- 7	81	12- 3	32	11-12	27	5-12	12	1- 9	3	0- 0	0	0- 0	0	0- 0	0	2
1914	105- 1	263	2-14	12	8-11	28	21- 6	59	18- 4	45	29- 7	64	14- 7	28	5-14	10	1-14	3	0- 0	0	0- 0	0	6
1915	89- 0	213	1- 2	5	2- 2	8	8- 5	26	12-14	34	20- 1	49	22- 5	48	14- 6	27	3- 8	6	1-12	3	0- 0	0	1
Average	**119.4**	**325**	**12.3**	**58**	**10.8**	**36**	**16.2**	**47**	**19.6**	**50**	**22.6**	**52**	**18.5**	**38**	**7.2**	**13**	**5.9**	**10**	**2.3**	**4**	**0**	**0**	**3**

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
130. Washington strain: Orchard grade—																							
1910	88-15	245																					
1911	94-10	226	4-12	19	6- 8	20	12- 6	34	22-12	56	20- 4	45	18-15	37	1-11	3	6-10	11	0-12	1	0- 0	0	
1912	102- 8	319	27- 1	111	28-10	90	14-14	42	19- 4	49	9- 0	20	2- 9	5	0- 0	0	1- 2	2	0- 0	0	0- 0	0	
1913	94-13	307	20- 4	100	14 14	55	18 8	57	14-10	38	14-11	34	8- 1	16	3- 4	6	0- 9	1	0- 0	0	0- 0	0	
1914	58-12	132	1- 9	6	1-14	6	6-13	19	9-12	24	21- 0	45	12- 6	23	4-12	8	0-10	1	0- 0	0	0- 0	0	
1915	80- 9	176	0- 0	0	2 10	9	8- 0	24	9 11	25	23- 6	53	10- 8	21	17 12	31	3-13	6	4-13	7	0- 0	0	
Average	**86.7**	**234**	**10.7**	**47**	**10.9**	**36**	**12.1**	**35**	**15.2**	**38**	**17.7**	**39**	**10.5**	**20**	**5.5**	**10**	**2.6**	**4**	**1.1**	**2**	**0**	**0**	
Standard grade—																							
1910	15- 7	46																					
1911	9-12	27	2- 5	10	0-11	2	2- 4	6	0- 7	1	2- 6	5	1- 1	2	0- 0	0	0-10	1	0- 0	0	0- 0	0	
1912	18-13	90	14- 0	76	2-14	9	0- 6	1	1- 9	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1913	19- 1	75	8- 8	44	4-15	17	1- 5	4	1- 9	4	1-12	4	1- 0	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1914	13-13	44	4- 8	22	0-10	2	3-11	10	0-14	2	1-14	4	2- 4	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1915	32- 6	77	1-10	7	1-12	6	3-14	11	3- 6	9	6-12	16	8-12	19	3-14	5	1- 2	2	1- 4	2	0- 0	0	
Average	**18.2**	**60**	**6.2**	**32**	**2.2**	**7**	**2.3**	**6**	**1.6**	**4**	**2.6**	**6**	**2.6**	**5**	**0.8**	**1**	**0.4**	**1**	**0.3**	**0.4**	**0**	**0**	
Cull fruits—																							
1910	0- 0	0																					
1911	4- 6	12																					
1912	6- 7	43																					
1913	15- 5	66																					
1914	2-10	14																					
1915	2- 2	8																					
Average	**5.2**	**24**																					

Total crop—																						
1910	104–6	291	5–6	24	15–6	53	16–0	51	21–11	59	24–0	59	14–0	30	6–12	13	0–9	1	0–10	1	0–0	0	....
1911	108–12	265	7–1	29	7–3	22	14–10	40	23–3	57	22–10	50	20–0	39	1–11	3	7–4	12	0–12	1	0–0	0	....
1912	127–12	452	41–1	187	31–8	99	15–4	43	20–13	53	9–0	20	2–9	5	0–0	0	1–2	2	0–0	0	0–0	0	3
1913	129–3	448	28–12	144	19–13	72	19–13	61	16–3	42	16–7	33	9–1	18	3–4	6	0–9	1	0–0	0	0–0	0	0
1914	75–3	190	6–1	28	2–8	8	10–8	29	10–10	26	22–14	49	14–10	27	4–12	8	0–10	1	0–0	0	0–0	0	5
1915	115–1	261	1–10	7	4–6	15	11–14	35	13–1	34	30–2	69	19–4	40	21–10	36	4–15	8	6–1	9	0–0	0	1
Average	**110.1**	**318**	**15.0**	**70**	**13.5**	**45**	**14.7**	**43**	**17.6**	**45**	**20.9**	**47**	**13.2**	**27**	**6.3**	**11**	**2.5**	**4**	**1.2**	**2**	**0**	**0**	**2**
131. Unproductive strain:																						
Orchard grade—																						
1910	51–8	123																				
1911	128–10	284	1–10	6	7–3	23	11–0	30	25–8	63	19–4	43	35–3	69	7–9	14	16–4	28	5–1	8	0–0	0	....
1912	114–7	355	29–7	119	29–14	96	15–10	45	26–1	66	6–14	16	6–0	12	0–9	1	0–0	0	0–0	0	0–0	0	....
1913	85–13	289	25–13	122	13–13	50	20–0	57	9–13	25	10–15	25	3–11	7	1–12	3	0–0	0	0–0	0	0–0	0	....
1914	53–1	117	0–0	2	3–6	11	9–0	25	8–10	21	12–4	26	11–6	20	6–8	10	1–7	2	0–0	0	0–0	0	....
1915	42–9	97	0–0	0	0–14	3	3–6	10	9–14	25	14–8	33	7–6	15	2–12	5	3–3	5	0–10	1	0–0	0	....
Average	**79.3**	**211**	**11.5**	**50**	**11.0**	**37**	**11.8**	**33**	**16.0**	**40**	**12.8**	**29**	**12.7**	**25**	**3.8**	**7**	**4.2**	**7**	**1.1**	**2**	**0**	**0**	....
Standard grade—																						
1910	13–2	34																				
1911	21–0	53	1–1	4	4–12	14	5–13	15	3–13	9	3–8	7	2–1	4	0–0	0	0–0	0	0–0	0	0–0	0	....
1912	37–15	166	25–7	130	5–11	18	2–13	8	2–5	6	1–11	4	0–0	0	0–0	0	0–0	0	0–0	0	0–0	0	....
1913	31–12	129	16–3	82	6–12	23	5–0	15	1–9	4	1–12	4	0–8	1	0–0	0	0–0	0	0–0	0	0–0	0	....
1914	13–11	38	1–15	10	3–0	9	2–10	7	0–7	1	2–7	5	2–10	5	0–10	1	0–0	0	0–0	0	0–0	0	....
1915	13–2	33	1–0	4	1–14	6	2–2	6	0–12	2	1–12	4	4–0	8	1–10	3	0–0	0	0–0	0	0–0	0	....
Average	**21.8**	**76**	**9.1**	**46**	**4.4**	**14**	**3.7**	**10**	**1.8**	**4**	**2.2**	**5**	**1.8**	**4**	**0.5**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	....
Cull fruits—																						
1910	0–0	0																				
1911	5–8	15																				
1912	10–14	64																				
1913	20–6	94																				
1914	3–4	17																				
1915	1–7	4																				
Average	**6.9**	**32**																				
Total crop—																						
1910	64–10	157	0–12	3	2–10	10	7–0	22	16–4	42	18–12	42	12–2	25	5–4	10	0–10	1	1–4	2	0–0	0	....
1911	155–2	352	2–11	10	11–15	37	16–13	45	29–5	72	22–12	50	37–4	73	7–9	14	16–4	28	5–1	8	0–0	0	....
1912	163–4	585	54–14	249	35–9	114	18–7	53	28–6	72	8–9	20	6–0	12	0–9	1	0–0	0	0–0	0	0–0	0	2
1913	137–15	512	42–0	204	20–9	73	25–0	72	11–6	29	12–11	29	4–3	8	1–12	3	0–0	0	0–0	0	0–0	0	0
1914	70–0	172	2–7	12	6–6	20	11–10	32	9–1	22	14–11	31	14–0	25	7–2	11	1–7	2	0–0	0	0–0	0	6
1915	57–2	134	1–0	4	2–12	9	5–8	16	10–10	27	16–4	37	11–6	23	4–6	8	3–3	5	0–10	1	0–0	0	0
Average	**108.0**	**319**	**17.3**	**80**	**13.3**	**44**	**14.1**	**40**	**17.5**	**44**	**15.6**	**35**	**14.2**	**28**	**4.4**	**8**	**3.6**	**6**	**1.1**	**2**	**0**	**0**	**2**

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
136. Washington strain:																							
Orchard grade—																							
1910	78- 6	194																					
1911	85-14	184	0-13	3	2-11	8	5- 2	14	18- 8	46	14- 9	33	21- 0	42	5- 1	9	9- 6	16	7-14	12	0-14	1	
1912	108-10	325	16- 6	68	30-10	99	18-11	54	27-10	71	8-10	20	5- 8	11	0- 9	1	0-10	1	0- 0	0	0- 0	0	
1913	102- 0	335	20- 8	101	16- 6	60	24- 5	76	16-13	45	16- 6	38	5-13	12	1- 2	2	0- 0	0	0-11	1	0- 0	0	
1914	57- 1	136	0-12	3	3-10	12	9- 8	27	9-13	24	21-10	48	8-12	17	1-12	3	1- 4	2	0- 0	0	0- 0	0	
1915	40-11	96	0- 0	0	1- 2	4	5- 2	15	8- 5	22	13- 2	30	7-14	16	3- 5	6	1- 3	2	0-10	1	0- 0	0	
Average	**78.8**	**212**	**7.7**	**35**	**10.9**	**37**	**12.6**	**37**	**16.2**	**42**	**14.9**	**34**	**9.8**	**20**	**2.4**	**4**	**2.5**	**4**	**1.8**	**3**	**0.2**	**0.2**	
Standard grade—																							
1910	12- 7	30																					
1911	17- 5	41	1- 3	5	1-14	6	3- 2	8	1-11	4	3- 4	7	3-10	7	0-10	1	1-15	3	0- 0	0	0- 0	0	
1912	17-10	71	9- 4	46	3-10	12	3- 2	9	1- 2	3	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1913	19- 5	81	10- 8	53	3-13	15	1- 5	4	1- 7	4	1 12	4	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1914	12-13	39	2- 9	13	1-13	6	3- 6	9	1-12	4	2- 6	5	0-15	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1915	29- 4	69	0- 5	2	0- 0	0	2-14	9	3-12	10	6- 4	16	7-11	17	3- 2	6	3- 8	6	1-12	3	0- 0	0	
Average	**18.1**	**55**	**4.8**	**24**	**2.2**	**8**	**2.8**	**8**	**2.0**	**5**	**2.8**	**7**	**2.6**	**5**	**0.8**	**1**	**1.1**	**2**	**0.4**	**1**	**0**	**0**	
Cull fruits—																							
1910	0- 0	0																					
1911	0- 0	0																					
1912	4-12	27																					
1913	12- 6	49																					
1914	3- 6	15																					
1915	3- 0	9																					
Average	**3.9**	**17**																					

Total crop—																								
1910	90–13	224	3– 3	13	2–12	9	7– 9	22	23– 9	63	26– 0	61	16– 0	34	8– 3	16	2–15	5	0– 0	0	0–10	1	....	
1911	103– 3	225	2– 0	8	4– 9	14	8– 4	22	20– 3	50	17–13	40	24–10	49	5–11	10	11– 5	19	7–14	12	0–14	1	....	
1912	131– 0	423	25–10	114	34– 4	111	21–13	63	28–12	74	9– 2	21	5– 8	11	0– 9	1	0–10	1	0– 0	0	0– 0	0	0	
1913	133–11	465	31– 0	154	20– 3	75	25–10	80	18– 4	49	18– 2	42	6– 5	13	1– 2	2	0– 0	0	0–11	1	0– 0	0	0	
1914	73– 4	190	3– 5	16	5– 7	18	12–14	36	11– 9	28	24– 0	53	9–11	19	1–12	3	1– 4	2	0– 0	0	0– 0	0	4	
1915	72–15	174	0– 5	2	1– 2	4	8– 0	24	12– 1	32	19– 6	46	15– 9	33	6– 7	12	4–11	8	2– 6	4	0– 0	0	1	
Average	**100.8**	**284**	**10.9**	**51**	**11.4**	**38**	**14.0**	**41**	**19.1**	**49**	**19.1**	**44**	**13.0**	**27**	**4.0**	**8**	**3.4**	**6**	**1.8**	**3**	**0.2**	**0.3**	**1**	
137. Unproductive strain:																								
Orchard grade—																								
1910	110– 9	291																						
1911	79– 5	156	0– 3	1	1–11	5	4– 3	11	8–12	21	13– 8	29	22–12	44	2–14	5	14– 2	23	11– 4	17	0– 0	0	....	
1912	107–10	330	26–13	106	31– 4	99	19– 9	55	19– 0	47	5–13	13	4– 0	8	0– 9	1	0–10	1	0– 0	0	0– 0	0	....	
1913	94–10	268	8– 2	36	15– 8	57	19–15	60	15– 5	40	16–11	38	13–14	28	3–15	7	1– 4	2	0– 0	0	0– 0	0	....	
1914	44–10	102	0– 0	0	2– 9	8	3– 0	8	12– 2	30	18– 8	40	7–14	15	0– 9	1	0– 0	0	0– 0	0	0– 0	0	....	
1915	41– 7	84	0– 0	0	0– 5	1	2– 0	6	4– 8	12	7– 8	17	11– 2	22	8– 0	14	3–12	6	2–12	4	1– 8	2	....	
Average	**79.7**	**205**	**7.0**	**29**	**10.3**	**34**	**9.5**	**28**	**11.9**	**30**	**12.4**	**27**	**11.9**	**23**	**3.2**	**6**	**4.0**	**6**	**2.8**	**4**	**0.3**	**0.4**	....	
Standard grade—																								
1910	15– 3	42																						
1911	15– 3	37	0–14	4	1–12	5	4– 7	12	2–10	5	3– 5	7	1– 0	2	0– 0	0	1– 3	2	0– 0	0	0– 0	0	....	
1912	8–15	48	7– 0	43	0–11	2	0– 0	0	0–12	2	0– 0	0	0– 8	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1913	16– 4	54	3–12	19	3–10	13	3– 3	9	2– 4	6	0–14	2	2– 0	4	0– 9	1	0– 0	0	0– 0	0	0– 0	0	....	
1914	13–14	48	5– 1	26	1– 4	4	2–14	8	2– 2	5	0–14	2	0– 8	1	1– 3	2	0– 0	0	0– 0	0	0– 0	0	....	
1915	17–14	36	0– 2	1	0– 0	0	0– 5	1	0– 6	1	2– 1	5	4– 2	9	5– 4	10	1–12	3	3– 3	5	0–11	1	....	
Average	**14.6**	**44**	**3.4**	**19**	**1.5**	**5**	**2.2**	**6**	**1.6**	**4**	**1.4**	**3**	**1.6**	**3**	**1.4**	**3**	**0.6**	**1**	**0.6**	**1**	**0.1**	**0.2**	....	
Cull fruits—																								
1910	0– 0	0																						
1911	4– 0	8																						
1912	5– 3	27																						
1913	20– 7	79																						
1914	2– 6	12																						
1915	3–10	10																						
Average	**5.9**	**23**																						
Total crop—																								
1910	125–12	333	6– 4	24	7–14	26	5– 5	15	32– 3	101	49– 4	116	21– 3	44	3– 4	6	0– 7	1	0– 0	0	0– 0	0	....	
1911	98– 8	201	1– 1	5	3– 7	10	8–10	23	11– 6	26	16–13	36	23–12	46	2–14	5	15– 5	25	11– 4	17	0– 0	0	....	
1912	121–12	405	33–13	149	31–15	101	19– 9	55	19–12	49	5–13	13	4– 8	9	0– 9	1	0–10	1	0– 0	0	0– 0	0	0	
1913	131– 5	401	11–14	55	19– 2	70	23– 2	69	17– 9	46	17– 9	40	15–14	32	4– 8	8	1– 4	2	0– 0	0	0– 0	0	0	
1914	60–14	162	5– 1	26	3–13	12	5–14	16	14– 4	35	19– 6	42	8– 6	16	1–12	3	0– 0	0	0– 0	0	0– 0	0	1	
1915	62–15	130	0– 2	1	0– 5	1	2– 5	7	4–14	13	9– 9	22	15– 4	31	13– 4	24	5– 8	9	5–15	9	2– 3	3	0	
Average	**100.2**	**272**	**9.7**	**43**	**11.1**	**36**	**10.8**	**31**	**16.7**	**45**	**19.7**	**45**	**14.8**	**30**	**4.4**	**8**	**3.8**	**6**	**2.9**	**4**	**0.4**	**0.5**	**0.3**	

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
141. Unproductive strain:																							
Orchard grade—																							
1910	51- 7	117																					
1911	98- 0	219	3- 0	11	5–15	18	6–14	19	21- 6	53	15- 0	33	23- 4	46	7- 9	14	10- 8	18	4- 8	7	0- 0	0	....
1912	109- 4	335	23- 6	97	25- 9	82	20–14	61	22–11	59	10–12	24	4- 6	9	1- 1	2	0- 9	1	0- 0	0	0- 0	0	....
1913	88- 1	303	21- 6	106	14–12	54	24- 4	75	11- 8	31	13- 0	31	1- 8	3	1–11	3	0- 0	0	0- 0	0	0- 0	0	....
1914	43- 6	92	0- 4	1	1- 9	5	5- 6	15	9- 8	23	15- 6	32	6- 2	11	4- 9	4	0–10	1	0- 0	0	0- 0	0	....
1915	29–15	64	0- 0	0	0–14	3	2- 2	6	3–14	10	6- 6	14	9- 0	18	4–10	8	2- 7	4	0–10	1	0- 0	0	....
Average	**70.0**	**188**	**9.6**	**43**	**9.7**	**32**	**11.9**	**35**	**13.8**	**35**	**12.1**	**27**	**8.9**	**17**	**3.9**	**6**	**2.8**	**5**	**1.0**	**2**	**0**	**0**	....
Standard grade—																							
1910	9- 6	23																					
1911	15- 7	39	2- 4	8	2–12	8	2–12	7	2–15	7	2- 7	5	1–11	3	0–10	1	0- 0	0	0- 0	0	0- 0	0	....
1912	16- 1	69	9- 2	50	2- 8	8	1- 0	3	1- 9	4	1- 6	3	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	31- 3	124	14- 0	76	4–11	17	4- 6	13	1- 2	3	2–15	7	3- 7	7	0- 0	0	0–10	1	0- 0	0	0- 0	0	....
1914	5–15	22	2- 0	12	0- 0	0	2- 5	6	0–12	2	0–14	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	37–13	84	0- 4	2	0- 4	1	2–15	9	1–12	5	4–12	12	9- 8	21	10–15	21	6- 2	11	0–10	1	0–11	1	....
Average	**19.3**	**60**	**5.5**	**30**	**2.0**	**7**	**2.7**	**8**	**1.6**	**4**	**2.5**	**6**	**3.0**	**6**	**2.3**	**4**	**1.4**	**2**	**0.1**	**0.2**	**0.1**	**0.2**	....
Cull fruits—																							
1910	0- 0	0																					
1911	1- 8	5																					
1912	5- 4	42																					
1913	10- 3	59																					
1914	0- 8	3																					
1915	1–12	4																					
Average	**3.2**	**19**																					

Total crop—																						
1910	60–13	140	0–13	4	3– 0	10	3–12	11	8–14	24	18– 0	41	9–12	20	10– 1	19	5–15	10	0–10	1	0– 0	0	....
1911	114–15	263	5– 4	19	8–11	26	9–10	26	24– 5	60	17– 7	38	24–15	49	8– 3	15	10– 8	18	4– 8	7	0– 0	0	....
1912	130– 9	446	32– 8	147	28– 1	90	21–14	64	24– 4	63	12– 2	27	4–14	10	1– 1	2	0– 9	1	0– 0	0	0– 0	0	1
1913	129– 7	486	35– 6	182	19– 7	71	28–10	88	12–10	34	15–15	38	4–15	10	1–11	3	0–10	1	0– 0	0	0– 0	0	4
1914	49–13	117	2– 4	13	1– 9	5	7–11	21	10– 4	25	16– 4	34	6– 2	11	4– 9	4	0–10	1	0– 0	0	0– 0	0	3
1915	69– 8	152	0– 4	2	1– 2	4	5– 1	15	5–10	15	11– 2	26	18– 8	39	15– 9	29	8– 9	15	1– 4	2	0–11	1	0
Average	**92.5**	**267**	**12.7**	**61**	**10.3**	**34**	**12.8**	**37**	**14.3**	**37**	**15.2**	**34**	**11.5**	**23**	**6.8**	**12**	**4.5**	**8**	**1.1**	**2**	**0.1**	**0**	**2**
145. Unproductive strain:																						
Orchard grade—																						
1910	50– 6	130	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	71– 8	146	0– 2	1	3– 0	9	4– 8	12	11–10	28	13– 5	29	17–12	34	4– 0	7	7–15	13	9– 4	13	0– 0	0	....
1912	91– 7	269	20–15	84	21– 4	67	11– 8	32	17–10	44	10–12	24	8– 3	16	0– 9	1	0–10	1	0– 0	0	0– 0	0	....
1913	69–15	218	12– 7	58	12–14	46	15– 5	47	11– 2	29	10–14	24	5– 0	10	2– 5	4	0– 0	0	0– 0	0	0– 0	0	....
1914	30– 8	69	0–15	4	1– 8	5	4– 6	12	5–12	14	8– 9	18	6–12	12	2– 0	3	0–10	1	0– 0	0	0– 0	0	....
1915	27–13	60	0– 0	0	0– 8	2	1– 6	4	6– 0	15	6– 4	14	6– 9	13	5– 4	9	1– 4	2	0–10	1	0– 0	0	....
Average	**56.9**	**149**	**6.9**	**29**	**7.8**	**26**	**7.4**	**21**	**10.4**	**26**	**10.0**	**22**	**8.9**	**17**	**2.8**	**5**	**2.1**	**3**	**2.0**	**3**	**0**	**0**	....
Standard grade—																						
1910	10– 6	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	8– 9	19	0– 0	0	1–11	5	1– 9	4	1– 6	3	0– 7	1	1– 8	3	0– 0	0	2– 0	3	0– 0	0	0– 0	0	....
1912	23–12	98	13– 9	68	5–14	19	1– 6	4	2– 0	5	0– 7	1	0– 8	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	38–15	67	20–11	11	7– 0	25	6– 2	18	3– 6	9	1– 4	3	0– 8	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1914	12– 3	36	1–12	8	2–13	9	4– 6	12	1–11	4	0–15	2	0– 0	0	0– 0	0	0–10	1	0– 0	0	0– 0	0	....
1915	8– 6	21	0–12	3	0–10	2	1–12	5	0– 6	1	0–14	2	2– 6	5	1–10	3	0– 0	0	0– 0	0	0– 0	0	....
Average	**17.0**	**45**	**5.4**	**18**	**3.6**	**12**	**3.0**	**9**	**1.8**	**4**	**0.8**	**2**	**1.0**	**2**	**0.3**	**1**	**0.5**	**1**	**0**	**0**	**0**	**0**	....
Cull fruits—																						
1910	0– 0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	5–12	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912	7– 3	56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	11– 0	49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	3– 2	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	0– 6	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**4.6**	**23**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																						
1910	60–12	160	3– 4	13	4–14	15	8–12	25	13– 0	39	21–14	50	6–12	14	1– 2	2	1– 2	2	0– 0	0	0– 0	0	....
1911	85–13	177	0– 2	1	4–11	14	6– 1	16	13– 0	31	13–12	30	19– 4	37	4– 0	7	9–15	16	9– 4	13	0– 0	0	....
1912	122– 6	423	34– 8	152	27– 2	86	12–14	36	19–10	49	11– 3	25	8–11	17	0– 9	1	0–10	1	0– 0	0	0– 0	0	1
1913	119–14	334	33– 2	69	19–14	71	21– 7	65	14– 8	38	12– 2	27	5– 8	11	2– 5	4	0– 0	0	0– 0	0	0– 0	0	0
1914	45–13	122	2–11	12	4– 5	14	8–12	24	7– 7	18	9– 8	20	6–12	12	2– 0	3	1– 4	2	0– 0	0	0– 0	0	2
1915	36– 9	83	0–12	3	1– 2	4	3– 2	9	6– 6	16	7– 2	16	8–15	18	6–14	12	1– 4	2	0–10	1	0– 0	0	0
Average	**78.5**	**217**	**12.4**	**42**	**10.3**	**34**	**10.2**	**29**	**12.3**	**32**	**12.6**	**28**	**9.3**	**18**	**2.8**	**5**	**2.4**	**4**	**1.6**	**2**	**0**	**0**	**0.8**

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
148. Unproductive strain:																							
Orchard grade—																							
1910	75- 5	189																					
1911	66- 0	135	0- 6	2	1-14	6	3-10	10	9- 4	22	12- 0	25	21-10	42	2-11	5	8- 8	14	6- 1	9	0- 0	0	
1912	103- 3	353	43- 2	174	34- 6	110	12-15	37	10- 8	27	1-12	4	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1913	40- 1	95	0- 8	2	2- 9	9	6- 6	19	6-11	17	10- 7	24	4-11	9	7- 8	13	0-10	1	0-11	1	0- 0	0	
1914	12-11	34	0- 8	2	2-12	9	2-12	8	2- 5	6	2- 4	5	2- 2	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1915	32-11	80	0- 4	1	1- 2	4	5- 2	15	7- 3	19	11- 4	26	5- 6	11	2- 6	4	0- 0	0	0- 0	0	0- 0	0	
Average	**55.0**	**148**	**9.0**	**36**	**8.5**	**28**	**6.2**	**18**	**7.2**	**18**	**7.5**	**17**	**6.9**	**13**	**2.5**	**4**	**1.8**	**3**	**1.4**	**2**	**0**	**0**	
Standard grade—																							
1910	15-12	43																					
1911	10-13	26	0- 8	3	1- 0	3	1- 8	4	3- 2	7	2-14	6	0- 8	1	0-10	1	0-11	1	0- 0	0	0- 0	0	
1912	14- 8	73	11-11	64	2- 1	7	0-12	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1913	16- 6	43	1- 2	5	2- 6	8	2-13	8	1-10	4	4-12	11	2- 0	4	1- 1	2	0-10	1	0- 0	0	0- 0	0	
1914	0- 8	2	0- 8	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1915	9-11	26	0- 7	2	0- 8	2	3-12	11	0- 6	1	2- 2	5	2- 8	5	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
Average	**11.3**	**36**	**2.9**	**13**	**1.2**	**4**	**1.8**	**5**	**1.1**	**2**	**2.0**	**4**	**1.0**	**2**	**0.2**	**1**	**0.3**	**0.4**	**0**	**0**	**0**	**0**	
Cull fruits—																							
1910	0- 0	0																					
1911	3-13	9																					
1912	1- 3	11																					
1913	4- 9	17																					
1914	7- 4	40																					
1915	2- 8	9																					
Average	**3.2**	**11**																					

Total crop—																						
1910	91–1	232	0–12	3	4–13	17	16–2	49	20–10	55	18–12	45	23–10	51	5–4	10	1–2	2	0–0	0	0–0	0	....
1911	80–10	170	0–14	5	2–14	9	5–2	14	12–6	29	14–14	31	22–2	43	3–5	6	9–3	15	6–1	9	0–0	0	....
1912	118–14	437	54–13	238	36–7	117	13–11	39	10–8	27	1–12	4	0–8	1	0–0	0	0–0	0	0–0	0	0–0	0	1
1913	61–0	155	1–10	7	4–15	17	9–3	27	8–5	21	15–3	35	6–11	13	8–9	15	1–4	2	0–11	1	0–0	0	0
1914	20–7	76	1–0	4	2–12	9	2–12	8	2–5	6	2–4	5	2–2	4	0–0	0	0–0	0	0–0	0	0–0	0	0
1915	44–14	115	0–11	3	1–10	6	8–14	26	7–9	20	13–6	31	7–14	16	2–6	4	0–0	0	0–0	0	0–0	0	2
Average	**69.5**	**198**	**10.0**	**43**	**8.9**	**29**	**9.3**	**27**	**10.3**	**26**	**11.0**	**25**	**10.5**	**22**	**3.3**	**6**	**1.9**	**3**	**1.1**	**2**	**0**	**0**	**0.8**
150. Unproductive strain: Orchard grade—																						
1910	14–0	42																				
1911	57–2	140	2–10	10	7–14	24	7–5	21	12–8	31	7–10	17	12–10	25	3–11	7	2–14	5	0–0	0	0–0	0	....
1912	48–2	146	8–14	34	17–1	55	8–4	23	8–6	21	4–2	10	1–7	3	0–0	0	0–0	0	0–0	0	0–0	0	....
1913	63–1	178	7–0	31	8–2	28	17–11	51	8–14	23	12–4	28	5–10	11	2–14	5	0–10	1	0–0	0	0–0	0	....
1914	43–0	110	1–6	5	4–3	14	9–14	28	10–3	26	10–2	23	6–2	12	1–2	2	0–0	0	0–0	0	0–0	0	....
1915	57–6	134	0–4	1	1–8	5	4–14	14	15–4	39	18–10	43	5–12	12	8–8	16	0–9	1	1–6	2	0–11	1	....
Average	**47.1**	**125**	**4.0**	**16**	**7.8**	**25**	**9.6**	**27**	**10.8**	**28**	**10.6**	**24**	**6.3**	**13**	**3.2**	**6**	**0.8**	**1**	**0.3**	**0.4**	**0.1**	**0.2**	....
Standard grade—																						
1910	0–12	3																				
1911	9–11	28	1–10	8	1–10	5	1–13	5	1–10	4	1–14	4	0–8	1	0–0	0	0–10	1	0–0	0	0–0	0	....
1912	15–1	58	9–4	40	4–1	13	0–15	3	0–6	1	0–7	1	0–0	0	0–0	0	0–0	0	0–0	0	0–0	0	....
1913	14–6	52	4–7	23	4–2	14	2–8	7	2–13	7	0–0	0	0–8	1	0–0	0	0–0	0	0–0	0	0–0	0	....
1914	10–6	32	3–1	13	1–14	6	2–3	6	0–13	2	1–7	3	1–0	2	0–0	0	0–0	0	0–0	0	0–0	0	....
1915	19–10	50	1–8	6	1–12	6	1–10	5	2–3	6	3–8	9	5–2	11	2–2	4	0–9	1	0–9	1	0–11	1	....
Average	**11.7**	**37**	**4.0**	**18**	**2.7**	**9**	**1.8**	**5**	**1.6**	**4**	**1.5**	**3**	**1.4**	**3**	**0.4**	**1**	**0.2**	**0.4**	**0.1**	**0.2**	**0.1**	**0.2**	....
Cull fruits—																						
1910	0–0	0																				
1911	1–5	4																				
1912	3–2	13																				
1913	9–8	36																				
1914	6–3	31																				
1915	3–8	12																				
Average	**3.9**	**16**																				
Total crop—																						
1910	14–12	45	2–0	8	1–8	9	3–0	9	3–2	8	3–4	7	1–6	3	0–8	1	0–0	0	0–0	0	0–0	0	....
1911	68–2	172	4–4	18	9–8	29	9–2	26	14–2	35	9–8	21	13–2	26	3–11	7	3–8	6	0–0	0	0–0	0	....
1912	66–5	217	18–2	74	21–2	68	9–3	26	8–12	22	4–9	11	1–7	3	0–0	0	0–0	0	0–0	0	0–0	0	5
1913	86–15	266	11–7	54	12–4	42	20–3	58	11–11	30	12–4	28	6–2	12	2–14	5	0–10	1	0–0	0	0–0	0	0
1914	59–9	173	4–7	18	6–1	20	12–1	34	11–0	28	11–9	26	7–2	14	1–2	2	0–0	0	0–0	0	0–0	0	4
1915	80–8	196	1–12	7	3–4	11	6–8	19	17–7	45	22–2	52	10–14	23	10–10	20	1–2	2	1–15	3	1–6	2	1
Average	**62.7**	**178**	**7.0**	**30**	**9.0**	**30**	**10.0**	**28**	**11.0**	**28**	**10.6**	**24**	**6.7**	**13**	**3.1**	**6**	**0.9**	**1**	**0.3**	**1**	**0.2**	**1**	**3**

TABLE III.—*Detailed statement of the annual performance of 35 representative Washington Navel orange trees for which records were obtained for six years, 1910 to 1915, inclusive, as summarized in Table II*—Continued.

Rank in Table II, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
151. Unproductive strain:																							
Orchard grade—																							
1910	27- 4	56																					
1911	69- 7	112	0- 0	0	0- 0	0	0- 0	0	2-15	7	4-14	10	13- 5	25	2- 3	4	18- 6	29	18- 2	26	9-10	11	
1912	36- 0	82	0- 8	2	0-15	3	1-14	5	6-12	16	5- 4	11	6- 5	22	3- 7	6	8- 1	13	2-14	4	0- 0	0	
1913	14- 3	34	0- 8	2	0- 5	1	1- 6	4	4-12	12	3- 2	7	3- 0	6	1- 2	2	0- 0	0	0- 0	0	0- 0	0	
1914	27-13	55	0- 4	1	0-10	2	0-12	2	1- 4	3	10-13	23	7- 3	13	6- 4	10	0- 0	0	0-11	1	0- 0	0	
1915	35-13	76	0- 0	0	0- 0	0	0-11	2	1-14	5	12-12	29	13- 8	28	3-14	7	1-12	3	0- 0	0	1- 6	2	
Average	**35.1**	**69**	**0.3**	**1**	**0.4**	**1**	**0.9**	**3**	**3.5**	**9**	**7.4**	**16**	**8.7**	**19**	**3.4**	**6**	**5.6**	**9**	**4.3**	**6**	**2.2**	**3**	
Standard grade—																							
1910	15- 0	32																					
1911	10- 2	16	0- 0	0	0- 0	0	0- 0	0	0- 0	0	1- 8	3	1-12	3	0- 9	1	3- 1	5	3- 4	4	0- 0	0	
1912	12- 5	27	0-10	2	1- 7	4	0-14	2	2- 2	5	3- 7	7	3- 4	6	0- 9	1	0- 0	0	0- 0	0	0- 0	0	
1913	5-13	19	1- 3	5	2- 5	8	0-12	2	1- 2	3	0- 7	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1914	4- 6	11	0- 5	2	0- 0	0	1- 4	3	1- 4	3	0- 0	0	1- 9	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	
1915	62- 6	154	1-12	10	2- 0	7	11- 2	32	4-14	13	15-14	38	20- 8	43	3-15	7	2- 5	4	0- 0	0	0- 0	0	
Average	**18.3**	**43**	**0.8**	**4**	**1.3**	**4**	**2.7**	**8**	**1.9**	**5**	**4.3**	**10**	**5.4**	**11**	**1.0**	**2**	**1.1**	**2**	**0.7**	**1**	**0**	**0**	
Cull fruits—																							
1910	0- 0	0																					
1911	1- 8	3																					
1912	3- 2	8																					
1913	4- 3	16																					
1914	1- 0	3																					
1915	4-10	13																					
Average	**2.4**	**7**																					

| Total crop— | | |

The following notes regarding some of the methods of compiling Table III may assist the reader in understanding it.

During the season of 1910 when these investigations were begun, the fruit of the several sizes was not separated into the Orchard and Standard grades and no record of the fruit of the Cull grade was made in securing the data, but in determining the average annual production of cull fruit the 6-year period was used as a basis, so that the results would be comparable with the averages for the other grades and the total crop.

Variable fruits were first recorded during the season of 1912. In succeeding years the observers gradually became familiar with an increasing number of forms of such variations and recorded them as they were observed. This accounts for the general increase from year to year in the number of such fruits recorded in these lists. This increase in the number of variable forms observed and recorded results in a lower average than would have been the case if all the forms had been recognized and recorded for the entire period of the investigation.

In expressing the averages of weights in these tables it was found impracticable to retain more than one decimal. The exact decimal expression of ounces as a fractional part of a pound extends to four places, but only one decimal place has been retained. In expressing the averages for the number of fruits occurring in different groups, no decimal has been retained except when the average number is less than unity. Hence, it will be found that the totals of averages will sometimes vary slightly from the average of the totals of the corresponding numbers.

The fruits of the Cull grade are not assorted into sizes, and on this account the total figures for the weights and numbers of fruits of the various sizes represent only the commercial crops of the trees.

A very heavy freeze occurred over most of the citrus sections of southern California in the winter of 1912–13, resulting in more or less injury to the foliage or trees in many groves. In nearly all localities many mature fruits on the trees were frozen, so that they became partly dry and hollow. Where it was possible to distinguish the frozen fruits from the sound ones they were assorted into the Cull grade, which accounts for the large number of cull fruits in the records of many of the trees for the year 1913.

In order to show the method of interpreting these individual-tree performance records and of applying the knowledge gained from them, the following discussion is presented of the data recorded from representative high and low producing trees of the Washington strain.

The records of tree No. 7: 2–37–1, listed in rank 11 in Tables II and III, show it to have produced an annual crop during the 6-year period averaging 298.8 pounds, and except for the reduced yield in the year of the freeze it produced a fairly uniform quantity each

season after the increase in 1911. Contrasted with this record is the annual average yield of 100.8 pounds produced by tree 7: 1–68–13, listed in rank 136 in the same tables. This tree also shows a fairly uniform crop throughout the periods, but with a reduced yield during the last two seasons.

It will be noticed that while the weight of the average crop of the tree ranked No. 11 is practically three times that of the other tree, the average number of fruits produced is only slightly more than twice as many. A determination of the average weight per fruit gives comparative results of 0.5 and 0.35 pound. The most desirable commercial sizes of the Washington Navel oranges are those which pack 126, 150, 176, and 200 to the box, the highest prices usually being received for the 126 and 150 sizes. A fruit weighing 0.5 pound is generally of the 150 size, while one weighing 0.35 pound is about size 200. An inspection of the number of fruits of the various sizes borne by the two trees shows that the tree ranked No. 11 had more of the 150 size than of any other, while the other tree produced the largest number of the 200 size. Comparing the number of fruits of the 126, 150, 176, and 200 sizes produced by the two trees, we find that the highest producing tree bore approximately 63 per cent of these desirable sizes, while the other tree had only 45 per cent of the same sizes.

A comparison of the relative proportions of high-grade fruit produced by these trees shows again the superior value of the high-producing tree, for it had 82.6 per cent of the Orchard grade, or first-grade, fruit, while the other tree had only 78.2 per cent of this grade. The number of variable fruits found on these trees was very small, being only 0.43 per cent of the total number of fruits in the case of the high-producing tree and 0.42 per cent on the other tree.

It will be seen that this and similar high-producing trees are of superior value, not only on account of their high production, but also because of their large proportion of fruit of the most desirable sizes and their high percentage of first-grade fruit. These conditions also make such trees of special value to the propagator as sources of bud wood for nursery propagation or for rebudding older trees of undesirable strains.

In Table IV are given the average total crops of the 481 trees in the record plats on which data have been secured for four successive years, and in Table V are presented the annual detailed performance records of 64 representative trees from this list. These tables are similar in character to Tables II and III, but they present data for a 4-year instead of a 6-year period. The trees listed in Table V were chosen on the same basis as those in Table III, but in order to reduce the length of the table it was necessary to omit some of the trees of the Thomson, Golden Nugget, and Yellow Washington strains.

TABLE IV.—*Summarized statement of the average annual production of 481 Washington Navel orange trees for which detailed performance records were obtained for four years, 1912 to 1915, inclusive.*

[Detailed performance records of the trees marked with an asterisk (*) are shown in Table V. The strain to which each tree belongs is shown by abbreviations, as follows: A=Australian, GN=Golden Nugget, ST=Sporting Thomson, SW=Sporting Washington, T=Thomson, TW=Thomson-Washington, U=Unproductive, W=Washington, Wr=Wrinkled, WrA=Wrinkled Australian, WT=Washington-Thomson, YT=Yellow Thomson, YW=Yellow Washington.]

Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.				Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.			
			Weight.	Number.	Orchard grade.	Variable fruits.				Weight.	Number.	Orchard grade.	Variable fruits.
			Lbs.		*P. ct.*	*P. ct.*				*Lbs.*		*P. ct.*	*P. ct.*
1	W...	*3-14-27	412.5	850	77.7	0.51	67	W...	4-26-13	263.8	603	78.5	1.08
2	W...	*3-12-28	410.9	1,036	76.0	.72	68	W...	SM- 3-25-12	262.9	704	77.4	.71
3	W...	11-52-13	406.7	945	84.1	.67	69	W...	9- 3- 4	262.8	566	80.5	1.06
4	W...	*11-52-15	388.5	905	83.4	.55	70	T....	5-38- 4	262.2	741	80.6	2.74
5	W...	*3-13-29	369.9	815	76.5	1.14	71	W...	10: 1-31- 4	260.4	577	79.5	.57
6	W...	*3-13-28	361.6	861	76.6	.70	72	W...	9- 6- 4	260.2	601	79.6	.58
7	W...	*3-23-27	349.8	874	77.9	.77	73	W...	*10: 1-31-10	260.1	597	75.9	.83
8	W...	3-12-29	348.3	788	77.8	.80	74	T....	5-37- 7	259.4	714	84.7	.49
9	W...	11-52-14	346.0	795	83.3	.88	75	W...	4-19-33	259.4	585	69.8	.94
10	W...	*3-12-30	338.5	721	73.1	.87	76	W...	10: 1-29-10	258.9	604	81.7	.41
11	W...	3-14-26	336.3	744	81.7	1.08	77	W...	7: 1-52-22	258.1	618	80.4	.61
12	GN..	*8-16-20	333.7	784	60.0	4.72	78	W...	10: 1-28- 6	256.6	562	83.1	.98
13	W...	*7:2-34- 2	326.7	742	75.1	.65	79	W...	10: 1-29- 3	256.6	584	80.9	.68
14	W...	3-22-27	323.2	762	80.3	.70	80	W...	10: 1-29-12	255.9	577	80.0	1.04
15	W...	11-52-12	321.8	784	84.1	1.15	81	W...	10: 1-28-12	255.8	614	83.3	.73
16	W...	*4-27-16	320.3	681	76.3	.73	82	W...	7: 1-57-10	254.9	644	82.9	.36
17	W...	7: 2-37- 1	312.4	647	78.8	.43	83	T....	5-41- 3	254.5	679	86.6	.44
18	W...	*7: 2-25- 1	309.2	686	80.6	.73	84	W...	4-18-19	254.3	604	71.3	.30
19	W...	10: 1-28- 9	307.7	852	80.9	.41	85	W...	7: 2-30- 3	254.2	584	82.8	.65
20	W...	3-13-25	304.8	661	77.8	.53	86	W...	SM- 3-30-17	253.6	713	81.0	1.26
21	W...	3-14-23	303.3	622	81.3	.56	87	W...	4-23- 2	253.2	525	81.0	.48
22	TW..	*5-41- 7	303.1	820	82.8	.46	88	W...	6: 1-58- 1	253.2	662	83.0	.38
23	W...	10: 1-29- 2	301.9	768	76.4	.59	89	TW..	5-39- 6	252.9	666	85.0	1.05
24	W...	*7: 2-30- 1	301.8	688	78.2	.65	90	W...	10: 1-28- 5	252.8	565	84.7	.94
25	W...	*7: 2-32- 3	289.5	676	73.1	.41	91	W...	7: 1-52-16	252.5	669	85.0	.19
26	T....	*5-36- 1	287.6	754	75.7	3.25	92	W...	4-23- 4	252.2	517	75.6	.68
27	W...	10: 1-29- 8	287.4	614	76.6	.98	93	W...	10: 1-32- 3	251.2	550	81.5	.42
28	W...	3-14-25	287.0	590	80.2	.98	94	T....	5-42- 7	251.2	572	88.5	1.57
29	W...	5-40- 4	286.6	825	84.9	1.61	95	T....	*5-41-17	251.1	743	84.3	1.18
30	TW..	5-41- 6	285.6	900	83.6	2.48	96	W...	10: 1-30- 7	250.5	545	75.8	.79
31	W...	10: 1-32- 6	285.0	652	81.9	.35	97	W...	*9- 4- 3	249.7	608	75.6	1.04
32	T....	5-40- 5	284.5	765	87.7	.78	98	T....	5-39- 4	249.3	780	87.2	1.22
33	W...	4-23- 3	281.4	602	78.8	.80	99	W...	3-17- 4	249.0	576	75.7	.57
34	W...	*9- 2- 5	280.7	631	84.5	.63	100	W...	7: 1-52-15	248.6	675	83.6	.19
35	W...	7: 2- 8- 1	279.1	591	82.0	.30	101	W...	10: 1-30- 2	248.3	576	81.8	1.79
36	W...	7: 2-17- 2	279.0	684	83.0	.56	102	W...	3-13- 4	247.3	532	77.8	.62
37	T....	5-38- 6	278.2	762	82.8	1.02	103	W...	10: 1-29- 7	246.5	587	81.3	.82
38	W...	7: 1-59-11	277.6	693	83.5	.26	104	W...	4-28-15	246.5	611	76.6	.38
39	W...	7: 2-25- 3	277.2	628	80.2	.29	105	W...	SM- 3-28-14	246.4	634	74.9	1.50
40	W...	10: 1-30- 9	275.8	582	80.9	2.23	106	T....	5-36- 7	246.1	661	82.8	.53
41	T....	5-42- 5	274.4	787	87.7	1.14	107	W...	10: 1-28-10	246.0	593	81.6	.59
42	W...	10: 1-30- 3	273.5	630	84.7	.31	108	ST..	*5-40- 2	245.0	730	76.9	7.30
43	W...	10: 1-28- 8	273.5	672	79.2	.45	109	W...	10: 1-32- 7	244.9	553	77.5	.87
44	T....	5-37- 3	273.4	766	82.2	1.24	110	T....	5-32- 5	244.9	698	70.9	1.19
45	W...	7: 2- 2- 1	273.1	625	80.3	.37	111	W...	10: 1-28- 4	244.7	556	81.4	.95
46	W...	7: 2-31- 1	273.1	638	77.8	.28	112	W...	SM- 3-24-15	244.6	692	72.3	.29
47	W...	7: 2-32- 1	272.9	593	84.8	.51	113	T....	5-41- 5	244.1	711	84.3	.49
48	W...	10: 1-31- 5	272.5	575	80.5	.52	114	T....	5-36- 6	243.2	680	79.3	.51
49	W...	10: 1-31- 7	272.5	641	76.3	.67	115	W...	7: 2-32- 4	242.0	508	77.8	1.14
50	W...	3-13-27	272.0	757	74.2	.58	116	W...	10: 1-32-11	242.0	530	84.5	.72
51	W...	10: 1-32-10	271.9	615	79.3	.41	117	W...	10: 1-31- 1	241.8	558	81.4	.68
52	T....	5-42- 2	271.6	800	81.2	5.63	118	W...	SM- 3-29-12	241.4	645	77.0	.78
53	W...	9- 2- 2	271.5	605	81.3	.96	119	T....	5-36- 4	241.3	697	82.1	.86
54	T....	*5-42- 3	271.5	779	83.8	1.22	120	W...	7: 1-57-15	240.7	620	84.3	.85
55	W...	7: 2-31- 2	271.1	625	83.1	.96	121	W...	10: 1-31- 6	240.4	529	81.8	.81
56	W...	10: 1-32- 9	270.3	637	80.5	.16	122	W...	9- 4- 6	240.4	529	80.4	1.38
57	W...	*9- 3- 6	269.9	648	83.8	.46	123	W...	*9- 5- 5	240.1	519	77.0	.64
58	W...	4-28-14	269.7	634	78.1	.60	124	W...	10: 1-29-11	240.1	646	84.0	.46
59	W...	SM- 3-26-14	269.2	668	78.6	.37	125	T....	5-40- 7	239.9	657	81.0	.81
60	W...	11-52-16	269.1	665	84.8	.49	126	W...	7: 2-30- 2	239.1	546	82.9	.27
61	W...	7: 1-52-20	265.8	700	80.3	.04	127	T....	5-39- 3	239.0	689	83.6	4.76
62	W...	10: 1-32- 4	265.4	580	79.5	.60	128	W...	7: 2-17- 1	238.9	563	79.5	.36
63	T....	5-38- 2	264.6	749	83.9	.53	129	W...	9- 2- 4	237.8	550	83.5	.91
64	W...	SM- 3-27-13	264.5	749	79.1	.47	130	T....	5-36- 5	237.7	673	81.6	3.31
65	W...	3-20-27	264.3	578	80.9	.78	131	W...	10: 1-32-12	237.4	526	76.3	.38
66	YT..	*5-29- 2	264.3	913	65.8	1.57	132	W...	9- 2- 6	237.4	590	80.7	.76

TABLE IV.—*Summarized statement of the average annual production of 481 Washington Navel orange trees for which detailed performance records were obtained for four years, 1912 to 1915, inclusive*—Continued.

Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.			
			Weight.	Number.	Orchard grade.	Variable fruits.
			Lbs.		*P. ct.*	*P. ct.*
133	W...	SM- 3-28-15	237.4	635	73.3	0.24
134	T....	5-36-11	237.3	650	80.1	1.05
135	W...	10: 1-29- 6	237.3	502	77.2	.50
136	W...	9- 5- 3	235.2	553	83.3	1.14
137	T....	5-39- 2	234.7	633	85.0	.71
138	W...	SM- 3-24-12	234.4	647	77.6	.93
139	W...	4-22- 3	234.3	496	81.9	.77
140	W...	7: 2-18- 1	234.0	549	77.1	.51
141	W...	SM- 3-28-13	234.0	612	76.2	.25
142	W...	10: 1-31- 2	233.5	502	78.7	.56
143	W...	SM- 3-26-12	233.5	563	76.7	.27
144	W...	10: 1-29- 4	233.4	477	77.7	1.53
145	W...	SM- 3-27-12	233.4	603	73.7	.50
146	T....	5-36- 3	232.9	676	77.4	.71
147	W...	10: 1-28- 2	232.8	516	79.7	.39
148	W...	7: 1-56-14	232.7	574	83.4	.49
149	T....	5-37- 5	232.6	664	82.8	.35
150	W...	SM- 3-28-20	232.4	575	82.1	.70
151	W...	7: 2-31- 3	231.8	525	77.0	.82
152	W...	SM- 3-29-15	231.5	617	78.5	.81
153	W...	SM- 3-31-13	230.9	624	76.5	.08
154	W...	10: 1-28- 3	230.8	533	77.7	.66
155	T....	*5-41- 4	230.6	645	85.6	.31
156	W...	*4-18-18	229.6	520	75.7	.87
157	W...	10: 1-28-11	229.5	548	84.4	1.24
158	T....	5-43- 4	228.9	666	86.2	1.05
159	W...	10: 1-28- 1	228.7	517	78.7	.97
160	W...	9- 5- 2	228.7	566	80.1	1.02
161	TW..	5-42- 6	227.4	688	84.8	.73
162	W...	3-14- 4	227.0	470	82.2	2.09
163	W...	4-19-32	227.0	551	72.3	.51
164	W...	10: 1-30- 8	226.7	507	79.7	1.35
165	W...	SM- 3-27-14	226.4	633	77.2	.87
166	T....	5-40- 3	226.3	657	85.8	.65
167	W...	7: 1-53- 1	226.0	540	79.5	.74
168	W...	10: 1-30- 5	225.9	433	83.6	1.15
169	W...	10: 1-30- 1	225.9	534	81.1	.34
170	W...	4-29-13	225.1	545	75.2	.55
171	W...	SM- 3-28-12	224.8	604	74.4	.83
172	W...	7: 1-52-17	224.7	540	81.3	.09
173	W...	7: 2-25- 5	224.4	499	78.3	.50
174	T....	5-43- 3	224.4	625	81.4	4.77
175	W...	7: 2- 1- 2	223.9	542	78.6	1.11
176	T....	5-38- 7	223.9	628	76.5	3.55
177	T....	5-38- 5	223.8	660	84.5	1.18
178	W...	4-32- 4	223.2	537	74.2	1.03
179	W...	7: 2-32- 5	222.7	474	81.8	.59
180	W...	9- 3- 2	222.3	547	80.8	.42
181	W...	SM- 3-29-14	222.0	612	79.3	.65
182	T....	5-41- 2	222.0	618	86.1	.86
183	W...	10: 1-31-11	221.5	527	78.3	.91
184	W...	SM- 3-31-17	220.7	542	76.5	1.29
185	W...	*10: 1-73- 3	220.2	554	75.0	.14
186	W...	7: 2-31- 4	219.6	466	78.6	.64
187	W...	10: 1-32- 2	219.6	479	80.4	.69
188	W...	10: 1-32- 1	219.6	502	79.3	.56
189	W...	SM- 3-30-18	219.3	527	77.3	.57
190	W...	7: 2-26- 5	219.1	519	80.2	.73
191	W...	7: 2- 1- 1	219.0	489	79.5	.71
192	W...	7: 2- 7- 2	218.4	545	84.7	.42
193	W...	9- 4- 2	218.3	523	76.5	.57
194	W...	3-21-28	218.1	453	80.0	2.20
195	ST..	5-32- 4	218.0	667	63.8	13.01
196	W...	10: 1-31- 9	217.7	452	78.8	1.24
197	W...	7: 2- 7- 1	217.0	536	77.2	.47
198	W...	7: 1-53-15	216.9	526	86.7	.48
199	W...	3-17- 3	216.5	497	77.3	.91
200	W...	10: 1-31-12	216.3	482	80.8	.52
201	W...	4-21-30	216.3	481	74.6	.27
202	G.N.	*8-17-21	216.1	467	62.9	7.18
203	W...	7:1-60-11	216.0	562	84.2	.45
204	T....	5-43- 6	216.0	601	80.7	4.68
205	W...	10: 1-32- 5	215.8	457	82.0	0.39
206	W...	7: 2-30- 4	215.1	469	82.0	.53
207	W...	7: 2-25- 2	214.9	488	79.7	.61
208	W...	SM- 3-32-16	214.7	558	77.3	1.08
209	GN..	8-18-18	214.5	425	62.7	9.88
210	W...	9- 5- 4	214.5	516	78.2	.87
211	W...	SM- 3-29-20	213.9	594	84.9	.59
212	W...	3-13-26	213.7	475	75.7	.48
213	W...	4-30- 6	213.2	451	77.5	2.39
214	W...	10: 1-32- 8	212.4	474	79.0	2.38
215	T....	5-36- 2	212.4	562	81.3	1.47
216	W...	SM- 3-25-13	212.1	607	78.3	.25
217	W...	10: 1-31- 3	212.0	452	81.3	.76
218	W...	10: 1-29- 1	212.0	484	81.7	1.20
219	W...	9- 3- 3	211.6	475	80.8	.70
220	W...	7: 2- 8- 2	211.2	544	86.3	.42
221	W...	7: 1-51-19	211.1	544	78.7	.28
222	W...	9- 4- 5	210.7	454	82.3	.77
223	W...	SM- 3-31-12	210.2	551	75.3	.54
224	W...	*7: 1-56-11	210.0	511	81.7	.45
225	W...	10: 1-31- 8	209.5	453	79.6	.84
226	W...	3-12-27	208.9	552	66.6	2.05
227	T....	5-40- 6	208.6	648	86.7	.93
228	W...	7: 1-65-21	207.6	584	75.9	.51
229	W...	SM- 3-25-14	207.1	509	77.9	.59
230	W...	6: 1-53- 2	206.7	555	82.0	.18
231	W...	5-34- 1	206.4	574	73.6	.84
232	W...	7: 2- 7- 3	205.9	476	83.9	.38
233	W...	9- 6- 2	205.9	496	86.6	.81
234	W...	7: 1-65-22	205.2	618	75.2	.53
235	W...	4-29- 6	204.6	426	74.1	1.64
236	W...	10: 1-30- 4	204.1	437	78.8	.57
237	W...	7: 2- 1- 4	204.1	446	78.1	.34
238	W...	7: 2- 2- 3	203.7	446	82.4	.78
239	W...	SM- 3-29-17	203.2	505	77.7	.68
240	W...	SM- 3-27-19	202.5	509	79.8	.42
241	T....	5-32- 3	202.5	640	69.0	1.95
242	W...	7: 2- 1- 3	202.3	454	80.2	.18
243	W...	SM-3-27-16	202.2	496	75.1	1.21
244	W...	SM-3-26-19	202.0	523	82.7	.29
245	W...	4-22-29	200.9	434	68.4	.57
246	W...	9- 4- 4	200.4	472	78.7	1.27
247	T....	*5-37- 6	199.9	611	83.7	.57
248	W...	*7:1-50-16	199.8	545	82.0	.24
249	GN..	*5-16-21	199.4	514	68.3	1.85
250	W...	3-14-24	199.3	403	80.8	.74
251	W...	6: 1-75- 1	198.5	530	80.1	.25
252	W...	7: 1-55-12	198.3	499	80.6	.56
253	W...	4-31- 2	198.1	449	69.8	.78
254	W...	7: 2- 2- 2	198.0	490	80.5	.73
255	W...	4-21-31	197.2	437	72.9	.57
256	W...	4-22- 5	196.5	402	78.4	.95
257	W...	SM- 3-24-19	195.6	488	74.6	.21
258	W...	SM- 3-28-17	195.2	520	78.8	3.08
259	W...	10: 1-30-12	195.1	446	78.0	.96
260	W...	9- 6- 3	194.8	428	85.9	.42
261	W...	SM- 3-27-17	194.2	507	77.7	.61
262	W...	7: 1-51-16	194.1	554	82.7	.23
263	W...	10: 1-30-16	193.1	410	79.3	.75
264	W...	9- 1- 2	193.0	426	77.5	.77
265	W...	7: 1-61-11	192.4	505	80.7	.18
266	T....	5-36-13	192.2	539	68.4	11.28
267	W...	6: 1-70- 9	192.0	481	80.5	.21
268	W...	10: 1-29- 5	190.8	426	81.3	.47
269	W...	*7: 2- 1- 5	190.7	489	81.0	.71
270	GN..	*8-16-24	189.2	401	58.2	5.74
271	W...	SM- 3-27-15	188.8	524	68.6	.19
272	W...	SM- 3-30-14	188.5	492	77.3	1.12
273	T....	5-39- 5	188.5	613	79.0	5.84
274	W...	SM- 3-30-19	188.4	468	79.7	.64
275	T....	5-39- 7	188.4	518	82.3	6.04
276	W...	10: 1-29- 9	187.7	394	81.4	.38
277	W...	4-23-28	187.5	431	70.1	.93

TABLE IV.—*Summarized statement of the average annual production of 481 Washington Navel orange trees for which detailed performance records were obtained for four years, 1912 to 1915, inclusive*—Continued.

Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.				Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.			
			Weight.	Number.	Orchard grade.	Variable fruits.				Weight.	Number.	Orchard grade.	Variable fruits.
			Lbs.		*P. ct.*	*P. ct.*				*Lbs.*		*P. ct.*	*P. ct.*
278	W...	7: 2-26- 3	186.2	411	79.3	0.80	350	W...	7: 2-25- 4	158.7	345	77.3	0.38
279	W...	3-16- 3	186.1	424	77.3	.35	351	W...	7: 2-26- 1	157.9	351	74.5	.71
280	W...	9- 5- 6	185.8	452	76.4	.66	352	YW.	SM- 3-28-19	157.7	384	73.4	1.04
281	W...	6: 1-71- 9	185.5	480	83.9	.21	353	W...	9- 6- 6	157.4	347	76.7	.58
282	W...	10: 1-28- 7	184.9	384	79.8	1.51	354	W...	SM- 3-31-15	155.2	416	72.2	.84
283	W...	4-17-34	184.3	383	70.1	.99	355	W...	7: 1-69-12	155.2	491	77.4	1.08
284	W...	7: 2- 2- 5	184.3	422	86.1	.59	356	W...	7: 1-51-17	154.5	389	84.9	.08
285	W...	4-17-33	184.2	394	74.3	.38	357	W...	SM- 3-26-15	154.2	371	77.8	.94
286	W...	SM- 3-29-19	184.2	520	83.9	.19	358	W...	7: 1-69- 8	154.0	481	77.4	.83
287	W...	V- 3-14- 3	182.9	397	81.5	9.32	359	W...	7: 2- 2- 4	153.9	397	80.9	.76
288	W...	SM- 3-31-21	181.9	455	82.5	.66	360	W...	SM- 3-27-18	153.6	401	76.6	.13
289	W...	SM- 3-30-13	181.5	458	74.3	.52	361	W...	7: 1-65- 6	153.6	430	74.7	.46
290	W...	SM- 3-29-18	181.5	544	80.7	.09	362	W...	7: 1-53-14	153.5	381	84.0	.97
291	W...	7: 1-55-11	180.7	405	80.9	.32	363	W...	SM- 3-32-13	153.4	388	73.7	.39
292	W...	SM- 3-24-14	180.6	498	78.3	.40	364	W...	6: 1-70- 8	152.2	388	79.2	1.55
293	W...	*7: 2-26- 4	180.3	425	83.4	.35	365	YW.	SM- 3-26-17	152.0	377	78.8	1.20
294	W...	4-16- 4	179.7	428	72.0	.42	366	W...	7: 1-57-11	150.9	367	83.5	.41
295	W...	4-22- 4	179.6	350	79.8	.71	367	W...	7: 1-65- 7	150.7	420	76.8	.48
296	W...	10: 2- 7-13	178.4	427	71.3	.35	368	W...	7: 1-69-13	150.7	434	81.4	.23
297	W...	3-18- 3	178.2	423	79.5	.66	369	W...	4- 3- 6	150.4	288	72.3	.54
298	W...	4-30- 5	177.3	376	72.6	1.33	370	W...	4-31- 3	150.4	355	65.8	1.92
299	W...	7: 1-56-12	176.4	486	76.6	1.39	371	WT.	*5-38- 3	150.4	424	85.6	.90
300	W...	3-16- 4	176.3	389	79.6	.39	372	W...	*7: 1-52-19	150.0	362	76.7	.55
301	W...	3-13- 3	175.9	419	77.9	.48	373	W...	4- 3- 5	149.1	321	74.4	.31
302	W...	SM- 3-25-19	175.9	437	74.4	.80	374	W...	4-32- 3	148.8	376	73.1	.97
303	W...	V- 3-21- 1	175.7	402	76.2	1.62	375	W...	10: 2- 7-14	148.0	343	77.8	.58
304	W...	6: 1-70-10	175.6	464	77.6	1.47	376	W...	7: 1-66-11	147.0	423	72.0	.31
305	W...	V- 3-18- 4	175.3	411	76.0	1.53	377	W...	4-18- 1	146.7	288	73.5	1.32
306	W...	SM- 3-26-18	174.8	446	79.6	.45	378	W...	9- 3- 5	146.7	300	81.9	2.10
307	W...	SM- 3-26-21	174.3	399	78.0	1.13	379	W...	7: 1-65-14	146.6	395	79.1	.96
308	W...	SM- 3-24-20	173.7	466	73.5	.64	380	W...	SM- 3-25-20	145.4	403	77.6	.75
309	T....	5-43- 5	173.3	500	75.7	3.36	381	W...	SM- 3-25-15	145.0	433	76.7	.23
310	T....	5-43- 8	173.1	473	81.9	3.17	382	W...	7: 1-65-15	144.2	398	78.9	.45
311	W...	7: 1-56- 4	172.9	423	87.5	.31	383	W...	6: 1-64- 4	144.1	368	84.7	.49
312	W...	SM- 3-24-18	172.8	400	76.6	.62	384	W...	SM- 3-29-13	144.1	368	75.0	2.31
313	W...	5-41-16	172.5	477	83.8	.42	385	W...	7: 2-31- 5	143.8	325	78.7	.56
314	W...	3-21-29	172.4	360	71.3	1.89	386	W...	SM- 3-33-17	143.4	321	74.4	2.19
315	W...	7: 1-65-10	172.3	457	75.6	1.09	387	W...	SM- 3-32-12	143.3	344	70.1	.15
316	W...	7: 1-69-11	272.2	504	81.8	.45	388	GN..	5-16-19	142.4	327	71.2	.76
317	W...	SM- 3-28-21	171.5	455	79.9	.44	389	W...	7: 1-66-13	142.2	384	75.9	1.17
318	W...	*SM- 3-32-14	170.3	436	72.9	.92	390	W...	4-22-28	141.6	323	65.5	.93
319	W...	SM- 3-26-20	169.7	429	82.0	.47	391	GN..	*5-17-23	140.7	427	60.6	1.05
320	W...	7: 1-65-13	169.7	484	74.2	.41	392	SW..	*10: 1-73- 2	140.0	351	36.8	49.52
321	W...	7: 2-26- 2	169.6	388	81.8	.46	393	W...	*9- 6- 5	139.8	312	81.9	1.92
322	W...	7: 1-65- 8	169.5	490	80.3	.41	394	T....	5-42- 4	137.7	429	77.3	4.15
323	W...	SM- 3-28-18	169.2	441	73.9	.45	395	W...	SM- 3-27-21	136.8	350	80.3	1.43
324	W...	9- 2- 3	169.1	372	86.0	.94	396	W...	7: 1-66- 9	136.1	398	70.8	.58
325	W...	4-31- 4	169.0	372	77.0	.75	397	W...	7: 1-69-10	136.1	416	79.2	.96
326	W...	SM- 3-26-16	167.1	402	78.7	.12	398	W...	SM- 3-24-16	135.6	388	76.4	2.71
327	T....	5-37- 2	166.4	457	80.8	.51	399	W...	SM- 3-24-21	135.3	344	75.2	1.74
328	W...	7: 1-53-13	166.1	394	85.6	.38	400	YW.	*3-31-19	135.1	312	77.1	1.12
329	W...	SM- 3-28-16	166.1	431	77.7	1.04	401	W...	7: 1-69-14	134.5	378	75.8	.40
330	W...	6: 1-69- 9	165.7	434	76.6	.18	402	YW.	SM- 3-31-16	134.3	314	73.2	.48
331	T....	5-37- 4	165.6	490	82.9	.82	403	W...	6: 1-70- 7	134.3	356	80.7	1.26
332	W...	7: 2-30- 5	165.1	356	80.0	.65	404	T....	*5-44- 8	133.8	460	80.6	1.15
333	W...	10: 1-30-11	164.7	399	81.1	1.70	405	W...	7: 1-65-11	131.8	366	77.8	.68
334	W...	6: 1-43- 5	163.5	458	85.1	.50	406	W...	7: 1-69-16	131.7	353	77.4	.71
335	W...	7: 1-69-17	163.3	449	75.3	.74	407	W...	7: 1-65- 9	130.9	381	78.3	.34
336	T....	5-34- 2	162.9	617	68.7	1.35	408	W...	*7: 1-69-15	130.0	373	75.4	.27
337	W...	V- 3-15- 4	162.5	382	79.4	.47	409	W...	7: 1-66-15	127.4	348	79.7	.81
338	W...	SM- 3-26-13	162.4	439	81.0	.34	410	W...	7: 1-65-12	127.1	360	80.5	.69
339	WrA	*7: 1-56-10	162.1	471	29.4	55.90	411	W...	3-15- 3	127.0	293	81.1	.68
340	W...	4-17-16	161.5	323	71.5	.62	412	WrA	*7: 1-56- 5	126.0	373	29.4	56.25
341	W...	7: 1-69- 6	161.5	489	72.1	.37	413	W...	SM- 3-30-12	122.0	341	76.6	.59
342	T....	*5-43- 7	161.4	604	77.8	1.21	414	W...	7: 1-66-14	121.7	369	77.1	.68
343	W...	7: 1-51-18	161.3	449	78.0	1.34	415	W...	7: 1-69- 9	121.7	387	71.5	1.16
344	W...	*4-20-33	160.1	336	69.1	.74	416	W...	7: 2-37- 2	121.0	257	76.3	.12
345	W...	SM- 3-24-13	159.9	409	77.2	.24	417	W...	SM- 3-24-17	120.6	279	74.3	.54
346	W...	7: 1-50-18	159.8	394	82.7	.25	418	YW.	*SM- 3-29-21	119.8	281	78.7	.89
347	YW.	*SM- 3-27-20	159.6	394	77.4	.63	419	W...	*7: 1-69- 7	119.7	370	68.7	1.03
348	GN..	5-15-21	159.5	401	73.9	1.12	420	U...	*6: 1-54- 2	119.4	309	74.8	.97
349	W...	4-20-32	159.2	417	72.4	.48	421	W...	SM- 3-33-16	119.0	281	80.1	1.42

TABLE IV.—*Summarized statement of the average annual production of 481 Washington Navel orange trees for which detailed performance records were obtained for four years, 1912 to 1915, inclusive*—Continued.

Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.				Rank.	Strain.	Tree designation.	Annual crop production, 4-year average.			
			Weight.	Number.	Orchard grade.	Variable fruits.				Weight.	Number.	Orchard grade.	Variable fruits.
			Lbs.		*P. ct.*	*P. ct.*				*Lbs.*		*P. ct.*	*P. ct.*
422	W...	SM- 3-31-20	118.3	342	81.0	0.88	452	U...	SM- 3-33-13	93.6	210	76.6	0
423	W...	7: 1-66- 7	117.6	329	77.0	.61	453	U...	10: 2- 6-12	93.1	210	72.7	.62
424	W...	SM- 3-25-21	117.2	293	77.1	1.88	454	U...	SM- 3-33-14	93.1	226	73.4	.22
425	W...	7: 1-67-11	117.2	359	80.7	.36	455	YW.	SM- 3-25-16	92.2	238	73.2	.84
426	W...	7: 1-66- 6	116.3	346	69.3	.87	456	U...	*7: 1-67- 8	91.5	294	73.0	.51
427	W...	7: 1-68-11	116.1	350	71.5	.80	457	YW.	*SM- 3-32-17	89.2	203	66.3	.98
428	W...	7: 1-68-15	114.8	320	77.2	1.34	458	U...	10: 2- 8-14	87.8	232	70.6	.13
429	W...	7: 1-52-18	114.2	308	83.9	.81	459	U...	7: 1-67- 9	87.8	279	66.2	3.05
430	W...	7: 1-67-14	111.9	338	79.4	.53	460	U...	10: 2- 6-13	87.5	211	64.3	1.33
431	W...	7: 1-67-15	111.8	338	75.3	.68	461	U...	7: 1-51-20	87.2	202	79.2	.25
432	W...	7: 1-67-10	111.4	350	74.7	.37	462	U...	7: 1-67- 6	85.8	273	79.5	1.28
433	W...	*10- 2- 8- 6	110.4	267	75.9	.11	463	U...	SM- 3-33-12	84.6	200	75.6	1.25
434	YW.	SM- 3-31-18	108.5	267	73.1	2.62	464	U...	7: 1-68- 8	81.1	241	67.7	.33
435	W...	6: 1-71- 8	107.1	289	81.1	.62	465	U...	*6: 1-64- 3	80.3	169	80.4	.59
436	U...	*7: 1-68- 7	107.1	351	69.1	.57	466	U...	SM- 3-33-15	78.4	201	73.5	.95
437	W...	4-32- 2	106.5	278	71.0	.36	467	U...	7: 1-68-14	76.9	247	67.1	.61
438	W...	7: 1-66- 8	106.4	344	70.1	.38	468	U...	6: 1-71- 7	76.8	197	75.5	1.67
439	YW.	SM- 3-30-16	105.2	252	74.7	.20	469	U...	7: 1-68-12	76.4	245	71.3	.53
440	W...	6: 1-69-10	105.0	255	81.9	3.84	470	U...	7: 1-66-10	76.0	214	67.5	.14
441	YW.	*SM- 3-25-18	104.7	262	77.3	.95	471	YW.	SM- 3-32-20	75.7	157	74.8	1.27
442	W...	7: 1-68-13	102.8	313	75.0	.41	472	U...	SM- 3-29-16	75.3	130	68.9	.77
443	W...	SM- 3-30-15	101.9	300	78.6	1.66	473	U...	6: 1-71-10	75.2	229	66.6	.13
444	W...	*7: 1-68- 6	101.2	321	69.4	1.03	474	U...	7: 1-66-12	74.6	215	58.6	2.33
445	U...	SM- 3-31-14	100.7	270	76.3	.56	475	U...	*7: 1-65-23	73.3	213	72.2	1.17
446	U...	*7: 1-68- 9	100.0	343	68.8	1.31	476	U...	7: 1-67-13	61.4	196	76.9	.41
447	U...	7: 1-67- 7	96.2	293	72.4	.85	477	U...	*7: 1-53-11	59.8	127	74.2	1.18
448	U...	7: 1-53-12	95.7	235	70.8	.13	478	YW.	*SM- 3-32-15	56.7	136	66.3	.37
449	U...	7: 1-68-10	94.8	300	71.3	.67	479	U...	7: 1-52- 3	52.9	125	53.9	1.60
450	U...	7: 1-67-12	94.2	274	76.5	.11	480	U...	10: 2- 7-17	52.8	117	68.2	.68
451	U...	10: 2- 8-15	93.9	251	64.3	3.59	481	U...	*6: 1-55- 5	48.3	118	73.7	1.27

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV.*

[The weights of the annual production are expressed in pounds and ounces, but the fractional averages are expressed decimally in pounds.]

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
1. Washington strain:																							
Orchard grade—																							
1912	315- 0	581	1- 5	5	2- 8	8	4- 5	12	27-13	68	29- 1	64	84- 5	163	28-15	52	77-14	128	41- 0	59	17-14	22	....
1913	152-14	310	0- 4	1	0- 5	1	7- 7	23	13-10	37	25- 3	59	34-14	72	41-14	74	14-11	23	6-14	10	7-12	10	....
1914	461- 8	946	1-10	8	5- 6	19	19-14	59	51-15	133	126-10	277	125-12	238	99- 6	167	21-14	33	8- 4	11	0-13	1	....
1915	352- 2	661	0- 0	0	0- 9	2	4-12	14	16- 4	43	36- 5	85	62-13	130	120- 9	217	57-13	94	34- 5	51	18-12	25	....
Average	**320.4**	**625**	**0.8**	**3**	**2.2**	**7**	**9.1**	**27**	**27.4**	**70**	**54.3**	**121**	**76.9**	**151**	**72.7**	**128**	**43.1**	**70**	**22.6**	**33**	**11.3**	**15**	....
Standard grade—																							
1912	23-11	57	2- 0	9	1-10	5	2-11	7	4-14	12	3-10	8	5-12	11	1- 3	2	1-15	3	0- 0	0	0- 0	0	....
1913	34- 7	80	0- 3	1	1- 8	5	3-10	11	2- 0	6	7- 3	18	12- 8	26	3- 3	6	1- 2	2	3- 2	5	0- 0	0	....
1914	24- 7	58	1- 1	6	0-15	3	2-10	7	2-12	7	6-12	16	4- 9	9	4- 8	8	1- 4	2	0- 0	0	0- 0	0	....
1915	78-12	151	0- 5	2	0- 9	2	2- 5	7	2- 4	6	5- 2	13	16- 8	35	19- 2	35	15- 6	26	11-14	18	5- 5	7	....
Average	**40.3**	**86**	**0.9**	**4**	**1.1**	**4**	**2.8**	**8**	**3.0**	**8**	**5.7**	**14**	**9.8**	**20**	**7.0**	**13**	**4.9**	**8**	**3.8**	**6**	**1.3**	**2**	....
Cull fruits—																							
1912	16- 3	41																					
1913	103-12	311																					
1914	17- 4	38																					
1915	69-13	165																					
Average	**51.8**	**139**																					
Total crop—																							
1912	354-14	679	3- 5	14	4- 2	13	7- 0	19	32-11	80	32-11	72	90- 1	174	30- 2	54	79-13	131	41- 0	59	17-14	22	0
1913	291- 1	701	0- 7	2	1-13	6	11- 1	34	15-10	43	32- 6	77	47- 6	98	45- 1	80	15-13	25	10- 0	15	7-12	10	0
1914	503- 3	1,042	2-11	14	6- 5	22	22- 8	66	54-11	140	133- 6	293	130- 5	247	103-14	175	23- 2	35	8- 4	11	0-13	1	8
1915	500 11	977	0- 5	2	1- 2	4	7- 1	21	18- 8	49	41- 7	98	79- 5	165	139-11	252	73- 3	120	46- 3	69	24- 1	32	9
Average	**412.5**	**850**	**1.7**	**8**	**3.4**	**11**	**11.9**	**35**	**30.3**	**78**	**60.0**	**135**	**86.8**	**171**	**79.7**	**140**	**47.9**	**78**	**26.4**	**39**	**12.6**	**16**	**4**

2. Washington strain:																								
Orchard grade—																								
1912	317- 3	744	6-12	25	24- 5	78	29- 7	84	74- 0	186	64-12	145	74- 9	150	10- 9	20	29- 7	50	3- 6	5	0- 0	0	....	
1913	225- 5	564	2- 3	10	9-11	38	30- 0	97	39-14	109	62- 6	151	42-14	90	33- 2	61	3- 2	5	1- 5	2	0-12	1	....	
1914	435- 6	1,083	5- 9	26	27- 0	93	69-12	208	85- 6	224	128- 3	298	85-15	176	29-10	52	3- 4	5	0-11	1	0- 0	0	....	
1915	270-14	599	0- 0	0	1- 5	5	11- 0	36	24- 7	69	62- 5	154	59-14	130	78- 3	150	19- 9	33	11-15	19	2- 4	3	....	
Average	**312.2**	**748**	**3.6**	**16**	**15.6**	**54**	**35.0**	**106**	**55.9**	**147**	**79.4**	**187**	**65.8**	**137**	**37.9**	**71**	**13.8**	**23**	**4.3**	**7**	**0.8**	**1**	....	
Standard grade—																								
1912	24- 2	75	8- 5	36	2-14	9	2- 9	7	3- 0	8	2-10	6	3- 0	6	1- 2	2	0-10	1	0- 0	0	0- 0	0	....	
1913	69- 1	212	9- 4	46	9- 8	35	13-14	43	6- 0	17	15- 6	39	9- 2	21	3- 8	7	2- 7	4	0- 0	0	0- 0	0	....	
1914	40- 6	116	4- 3	22	5-13	19	9-15	28	7- 3	18	6-15	16	5- 5	11	1- 0	2	0- 0	0	0- 0	0	0- 0	0	....	
1915	141-15	326	1-15	10	3- 4	12	8-10	27	11- 3	32	20- 5	52	49- 0	107	23- 0	44	13- 3	24	10- 0	16	1- 7	2	....	
Average	**68.9**	**182**	**5.9**	**29**	**5.4**	**19**	**8.8**	**26**	**6.8**	**19**	**11.3**	**28**	**16.6**	**36**	**7.2**	**14**	**4.1**	**7**	**2.5**	**4**	**0.4**	**0.5**	....	
Cull fruits—																								
1912	14- 2	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
1913	65- 6	251	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
1914	8-13	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
1915	30-14	97	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Average	**29.8**	**106**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Total crop—																								
1912	355- 7	866	15- 1	62	27- 3	87	32- 0	91	77- 0	194	67- 6	151	77- 9	156	11-11	22	30- 1	51	3- 6	5	0- 0	0	0	
1913	359-12	1,027	11- 7	56	19- 3	73	43-14	140	45-14	126	77-12	190	52- 0	111	36-10	68	5- 9	9	1- 5	2	0-12	1	6	
1914	484- 9	1,227	9-12	48	32-13	112	79-11	236	92- 9	242	135- 2	314	91- 4	187	30 10	54	3- 4	5	0-11	1	0- 0	0	11	
1915	443-11	1,022	1-15	10	4- 9	17	19-10	63	35-10	101	82-10	206	108-14	237	101- 3	194	32-12	57	21-15	35	3-11	5	15	
Average	**410.9**	**1,036**	**9.6**	**44**	**20.9**	**72**	**43.8**	**133**	**62.8**	**166**	**90.7**	**215**	**82.4**	**173**	**45.0**	**85**	**17.9**	**30**	**6.9**	**11**	**1.1**	**0.2**	**8**	
4. Washington strain:																								
Orchard grade—																								
1912	340- 3	783	5-10	21	19- 8	62	19-12	57	69-10	180	77- 2	178	93- 8	191	5-12	11	34- 5	60	13-10	21	1- 6	2	....	
1913	254-14	589	2- 6	9	8-15	29	36-15	105	40- 1	102	72- 1	164	59- 6	119	28- 0	50	4- 5	7	2- 0	3	0-13	1	....	
1914	334-15	824	4- 8	20	16-15	57	65- 4	189	78-13	200	105- 9	237	46- 0	90	16- 0	28	1-14	3	0- 0	0	0- 0	0	....	
1915	366-11	715	0- 0	0	2- 0	7	8- 7	26	14-10	40	48- 4	116	70- 0	149	99- 6	186	55-10	92	45-12	69	22-10	30	....	
Average	**324.2**	**728**	**3.1**	**13**	**11.8**	**39**	**32.6**	**94**	**50.8**	**131**	**75.8**	**174**	**67.2**	**137**	**37.3**	**69**	**24.0**	**41**	**15.3**	**23**	**6.2**	**8**	....	
Standard grade																								
1912	38-14	114	8- 5	36	4-15	16	7- 2	20	8- 0	20	5- 0	11	5- 8	11	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1913	70- 2	185	3- 6	14	7- 2	24	17- 3	50	11- 2	29	14-13	35	11- 6	24	3-12	7	0-10	1	0- 0	0	0-12	1	....	
1914	27- 8	98	7- 6	43	3- 1	11	7-12	22	4- 0	10	3- 0	7	2- 5	5	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1915	77- 0	170	4- 6	25	1- 4	5	3- 1	9	2-15	8	7- 6	17	18- 8	39	16- 1	30	8- 5	14	13-12	21	1- 6	2	....	
Average	**53.4**	**142**	**5.9**	**30**	**4.1**	**14**	**8.8**	**25**	**6.5**	**17**	**7.5**	**18**	**9.4**	**20**	**5.0**	**9**	**2.2**	**4**	**3.6**	**5**	**0.5**	**0.8**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																					
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
4. Washington strain—Con.																							
Cull fruits—																							
1912	16- 7	57																					
1913	15- 1	42																					
1914	5 9	25																					
1915	6-10	16																					
Average	**10.9**	**35**																					
Total crop—																							
1912	395- 8	954	13-15	57	24- 7	78	26-14	77	77-10	200	82- 2	189	99- 0	202	5-12	11	34- 5	60	13-10	21	1- 6	2	1
1913	340- 1	816	5 12	23	16- 1	53	54- 2	155	51- 3	131	86 14	199	70-12	143	31-12	57	4 15	8	2- 0	3	1- 9	2	1
1914	368- 0	947	11-14	63	20- 0	68	73- 0	211	82 13	210	168- 9	244	48- 5	95	16- 0	28	1-14	3	0- 0	0	0- 0	0	7
1915	450- 5	901	4- 6	25	3- 4	12	11- 8	35	17- 9	48	55-10	133	88- 8	188	115- 7	216	63-15	106	59- 8	90	24- 0	32	11
Average	**388.5**	**905**	**9.0**	**42**	**15.9**	**53**	**41.4**	**120**	**57.3**	**147**	**83.3**	**191**	**76.6**	**157**	**42.2**	**78**	**26.3**	**44**	**18.8**	**29**	**6.7**	**9**	**5**
5. Washington strain:																							
Orchard grade																							
1912	277- 2	554	1- 6	5	6- 6	20	8- 4	23	33-15	85	35- 8	80	78- 9	156	14-10	26	66- 0	111	23- 8	36	9- 0	12	....
1913	186- 8	406	0-14	3	3-12	15	12- 8	41	26- 1	69	36 12	87	33-12	70	45- 3	80	13-15	22	6-13	10	6-14	9	....
1914	435- 0	1,040	5- 7	25	17- 7	60	64-11	187	73-12	190	145 10	332	92- 2	183	33- 6	59	2- 9	4	0- 0	0	0- 0	0	....
1915	232-15	404	0- 0	0	0- 0	0	1- 8	5	5- 8	15	17-13	44	22 15	49	49- 8	92	45- 3	74	55- 8	83	35- 0	42	....
Average	**282.9**	**601**	**1.9**	**8**	**6.9**	**24**	**21.7**	**64**	**34.8**	**90**	**58.9**	**136**	**56.8**	**114**	**35.7**	**64**	**31.9**	**53**	**21.5**	**32**	**12.7**	**16**	....
Standard grade—																							
1912	10- 7	27	1- 5	6	0-10	2	0-12	2	2- 6	6	1-12	4	3- 1	6	0- 0	0	0- 9	1	0- 0	0	0- 0	0	....
1913	48-14	130	3- 1	15	4- 0	15	6- 2	20	6- 8	19	9- 9	25	8-11	18	6- 1	11	1- 4	2	1- 6	2	2- 4	3	....
1914	22-12	62	1- 4	7	4- 6	14	5- 8	15	3-10	9	4- 0	9	4- 0	8	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	133- 8	251	0- 3	1	1- 1	4	2- 8	8	2- 7	7	9- 0	23	25- 1	55	26- 5	50	21-10	36	32-14	51	12- 7	16	....
Average	**53.9**	**118**	**1.5**	**7**	**2.5**	**9**	**3.7**	**11**	**3.7**	**10**	**6.1**	**15**	**10.2**	**22**	**8.1**	**15**	**5.9**	**10**	**8.6**	**13**	**3.6**	**5**	....

Cull fruits—																								
1912	8- 1	20																						
1913	59- 6	199																						
1914	11-14	38																						
1915	53- 5	129																						
Average	**33.2**	**96**																						
Total crop—																								
1912	295-10	601	2-11	11	7- 0	22	9- 0	25	36- 5	91	37- 4	84	81-10	162	14-10	26	66- 9	112	23- 8	36	9- 0	12	2	
1913	294-12	735	3-15	18	7-12	30	18-10	61	32- 9	88	46- 5	112	42- 7	88	51- 4	91	15- 3	24	8- 3	12	9- 2	12	3	
1914	463-10	1,140	6-11	32	21-13	74	70- 3	202	77- 6	199	149-10	341	96- 2	191	33- 6	59	2- 9	4	0- 0	0	0- 0	0	11	
1915	419-12	784	0- 3	1	1- 1	4	4- 0	13	7-15	22	26-13	67	48- 0	104	75-13	142	66-13	110	88- 6	134	47- 7	58	21	
Average	**369.9**	**815**	**3.4**	**15**	**9.4**	**33**	**25.4**	**75**	**38.5**	**100**	**65.0**	**151**	**67.1**	**136**	**43.8**	**80**	**37.8**	**63**	**30.0**	**46**	**16.4**	**21**	**9**	
6. Washington strain:																								
Orchard grade—																								
1912	268- 2	585	4- 8	16	14-10	45	17-13	50	49- 1	121	45-13	102	73- 4	145	12- 2	22	37- 9	63	9- 6	16	4- 0	5		
1913	184-12	469	1-11	8	4- 5	15	27- 4	89	31-11	86	54-10	136	40- 9	89	23- 7	44	1- 3	2	0- 0	0	0- 0	0		
1914	369- 2	875	3-10	17	10-11	37	37- 6	112	63-12	170	133- 0	307	79-10	161	36- 0	63	4- 6	7	0-11	1	0- 0	0		
1915	286- 0	580	0- 0	0	1- 7	5	3-14	12	12-10	35	43- 6	106	62- 8	137	73- 9	144	41- 5	71	31- 1	48	16- 4	22		
Average	**277.0**	**627**	**2.5**	**10**	**7.8**	**26**	**21.6**	**66**	**39.3**	**103**	**69.2**	**163**	**64.0**	**133**	**36.3**	**68**	**21.1**	**36**	**10.3**	**16**	**5.1**	**7**		
Standard grade																								
1912	21-10	67	6- 7	29	1-13	6	3- 3	9	3-13	10	2- 3	5	3-10	7	0- 0	0	0- 9	1	0- 0	0	0- 0	0		
1913	52- 5	138	1-15	9	2-13	10	7- 4	23	4- 8	13	12- 7	32	13-12	32	7- 8	15	1- 8	3	0-10	1	0- 0	0		
1914	31-12	85	2-10	14	1-14	6	5-10	16	4- 6	11	9- 7	22	6- 3	13	1-10	3	0- 0	0	0- 0	0	0- 0	0		
1915	109-10	241	1- 3	9	1- 5	5	5-12	18	5- 5	15	14- 5	36	30- 9	67	23- 4	45	12-15	23	11- 6	18	3-10	5		
Average	**53.8**	**133**	**3.0**	**15**	**2.0**	**7**	**5.5**	**17**	**4.5**	**12**	**9.6**	**24**	**13.5**	**30**	**8.1**	**16**	**3.8**	**7**	**3.0**	**5**	**0.9**	**1**		
Cull fruits—																								
1912	11- 2	38																						
1913	60- 7	209																						
1914	5-10	17																						
1915	46- 0	140																						
Average	**30.8**	**101**																						
Total crop—																								
1912	300-14	690	10-15	45	16- 7	51	21- 0	59	52-14	131	48- 0	107	76-14	152	12- 2	22	38- 2	64	9- 6	16	4- 0	5	0	
1913	297- 8	816	3-10	17	7- 2	25	34- 8	112	36- 3	99	67- 1	168	54- 5	121	30-15	59	2-11	5	0-10	1	0- 0	0	1	
1914	406- 8	977	6- 4	31	12- 9	43	43- 0	128	68- 2	181	142- 7	329	85-13	174	37-10	66	4- 6	7	0-11	1	0- 0	0	4	
1915	441-10	961	1- 3	9	2-12	10	9-10	30	17-15	50	57-11	142	93- 1	204	96-13	189	54- 4	94	42- 7	66	19-14	27	19	
Average	**361.6**	**861**	**5.5**	**26**	**9.7**	**32**	**27.0**	**82**	**43.8**	**115**	**78.8**	**186**	**77.5**	**163**	**44.4**	**84**	**24.8**	**43**	**13.3**	**21**	**6.0**	**8**	**6**	

TABLE V. *Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Total.		Sizes. 288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
7. Washington strain:																							
Orchard grade—																							
1912	270- 1	605	7- 9	29	17 6	55	17- 1	48	50- 5	127	40- 5	91	72 14	144	14- 8	27	40- 6	69	9 11	15	0- 0	0	....
1913	118- 3	307	1- 2	6	4- 2	18	15- 6	55	16-15	54	29-10	74	21- 9	47	22- 0	42	3- 1	5	2- 1	3	2- 5	3	....
1914	397-10	929	4-12	24	12-13	44	44- 3	131	80- 6	207	121- 2	273	87 10	173	33- 0	57	10- 0	15	3 12	5	0- 0	0	....
1915	304- 2	705	0- 0	0	4- 0	14	25- 8	78	48-11	132	86- 3	205	76- 9	161	49 12	94	7 15	13	4 12	7	0 12	1	....
Average	**272.5**	**637**	**3.4**	**15**	**9.6**	**33**	**25.5**	**78**	**49.1**	**130**	**69.3**	**161**	**64.7**	**131**	**29.8**	**55**	**15.3**	**26**	**5.1**	**8**	**0.8**	**1**	....
Standard grade—																							
1912	19-12	66	9- 2	39	2- 2	7	1- 1	3	2- 6	6	4- 0	9	1- 1	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	66- 5	177	4- 3	25	3- 7	14	11- 7	39	5-15	18	8-10	23	14- 8	35	6- 5	13	3 15	7	1 4	2	0 11	1	....
1914	30- 7	79	2- 5	12	2- 2	7	3-13	11	3- 0	8	7- 8	18	8- 5	17	3- 6	6	0- 0	0	0- 0	0	0- 0	0	....
1915	40- 6	107	1- 5	7	3-11	13	10- 7	31	3- 4	9	8-11	21	7- 6	16	3-12	7	1- 3	2	0-11	1	0- 0	0	....
Average	**37.7**	**107**	**4.2**	**21**	**2.8**	**10**	**6.7**	**21**	**3.6**	**10**	**7.2**	**18**	**7.8**	**18**	**3.4**	**7**	**1.3**	**2**	**0.5**	**0.8**	**0.2**	**0.3**	....
Cull fruits—																							
1912	15- 7	58																					
1913	86- 1	291																					
1914	15- 6	42																					
1915	41-10	131																					
Average	**39.6**	**130**																					
Total crop—																							
1912	305- 4	729	16-11	68	19- 8	62	18- 2	51	52-11	133	44- 5	100	73 15	146	14- 8	27	40-6	69	9 11	15	0- 0	0	2
1913	264- 9	775	5- 5	31	7- 9	32	26-13	94	22 14	72	38- 4	97	36- 1	82	28- 5	55	7 0	12	3- 5	5	3- 0	4	2
1914	443- 7	1,050	7- 1	36	14 15	51	48- 0	142	83- 6	215	128 10	291	95-15	190	36- 6	63	10-0	15	3 12	5	0- 0	0	9
1915	386- 2	943	1- 5	7	7 11	27	35-15	109	51 15	141	94 14	226	83 15	177	53- 8	101	9-2	15	5- 7	8	0 12	1	13
Average	**349.8**	**874**	**7.6**	**36**	**12.4**	**43**	**32.2**	**99**	**52.7**	**140**	**76.5**	**178**	**72.5**	**149**	**33.2**	**62**	**16.6**	**28**	**5.5**	**8**	**0.9**	**1**	**7**

10. Washington strain:																								
Orchard grade—																								
1912	257- 3	501	2- 9	9	6-13	21	9-15	27	25- 4	62	34- 8	75	66- 7	130	15- 8	28	52- 5	87	33- 0	48	10-14	14	....	
1913	113- 4	235	0- 0	0	1- 7	5	3- 9	11	12- 7	33	22- 3	52	26- 5	53	30- 0	54	10-11	17	2-12	4	4- 8	6	....	
1914	401- 9	915	2-14	13	13- 8	46	48- 4	140	66-13	169	127- 9	284	98-15	190	38- 4	65	5- 6	8	0- 0	0	0- 0	0	....	
1915	217-14	383	0- 0	0	0- 0	0	0-10	2	3- 0	8	13- 6	31	26- 2	54	70- 9	136	42-12	67	38-15	57	22- 8	28	....	
Average	**247.5**	**509**	**1.4**	**6**	**5.4**	**18**	**15.6**	**45**	**26.9**	**68**	**49.4**	**111**	**51.5**	**107**	**38.6**	**71**	**27.8**	**45**	**18.7**	**27**	**9.5**	**12**	....	
Standard grade—																								
1912	13- 5	34	2- 1	9	1-14	6	1- 0	3	1-12	4	1- 7	3	2-11	5	0-10	1	1-14	3	0- 0	0	0- 0	0	....	
1913	35-12	82	0- 6	2	2-14	10	3-13	11	1- 9	4	6- 7	16	9-14	21	4- 5	8	3- 2	5	3- 6	5	0- 0	0	....	
1914	39-12	107	3- 3	17	5- 8	18	6-13	19	6- 6	16	5- 6	12	11- 6	23	1- 2	2	0- 0	0	0- 0	0	0- 0	0	....	
1915	93-12	167	0- 0	0	0- 0	0	1-15	6	2- 5	6	5- 0	12	18- 5	38	22- 0	40	18- 3	30	21-14	30	4- 2	5	....	
Average	**45.6**	**98**	**1.4**	**7**	**2.6**	**9**	**3.4**	**10**	**3.0**	**8**	**4.6**	**11**	**10.6**	**22**	**7.0**	**13**	**5.8**	**10**	**6.3**	**9**	**1.0**	**1**	....	
Cull fruits—																								
1912	15- 4	42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1913	68- 9	204	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1914	10- 4	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1915	87- 1	185	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
Average	**45.3**	**115**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
Total crop—																								
1912	285-12	577	4-10	18	8-11	27	10-15	30	27- 0	66	35-15	78	69- 2	135	16- 2	29	51- 3	90	33- 0	48	10-14	14	1	
1913	218- 3	521	0- 6	2	4- 5	15	7- 6	22	14- 0	37	28-10	68	36- 3	74	34- 5	62	13-13	22	6- 2	9	4- 8	6	5	
1914	451- 9	1,052	6- 1	30	19- 0	64	55- 1	159	73- 3	185	132-15	296	110- 5	213	39- 6	67	5- 6	8	0- 0	0	0- 0	0	7	
1915	398-11	735	0- 0	0	0- 0	0	2- 9	8	5- 5	14	18- 6	43	44- 7	92	92- 9	176	60-15	97	60-13	87	26-10	33	12	
Average	**338.5**	**721**	**2.8**	**13**	**8.0**	**26**	**19.0**	**55**	**29.8**	**76**	**54.0**	**121**	**65.0**	**129**	**45.6**	**83**	**33.6**	**51**	**24.9**	**36**	**10.5**	**13**	**6**	
12. Golden Nugget strain:																								
Orchard grade—																								
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1914	208-15	434	1- 4	5	7-12	25	16-12	46	22-15	55	45- 2	117	50- 4	92	37 12	59	13- 1	18	10- 7	13	3-10	4	....	
1915	191- 8	378	0- 0	0	0- 5	1	6- 6	19	16-11	43	38- 0	87	39- 5	80	51-15	92	14-11	23	13-12	20	10- 7	13	....	
Average	**200.2**	**406**	**0.6**	**3**	**4.0**	**13**	**11.6**	**33**	**19.8**	**49**	**41.6**	**102**	**44.8**	**86**	**44.8**	**76**	**13.9**	**21**	**12.1**	**17**	**7.0**	**9**	....	
Standard grade—																								
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1914	33-14	71	1- 0	5	1-10	5	5-10	15	4- 2	10	4- 8	9	6-11	12	5- 0	8	0-10	1	3-14	5	0-13	1	....	
1915	57- 7	131	1- 0	5	4- 7	15	8- 0	24	4-10	12	9-14	24	11-15	24	6-15	12	2- 9	4	6- 8	9	1- 9	2	....	
Average	**45.7**	**101**	**1.0**	**5**	**3.0**	**10**	**6.8**	**20**	**4.4**	**11**	**7.2**	**17**	**9.3**	**18**	**6.0**	**10**	**1.6**	**3**	**5.2**	**7**	**1.2**	**2**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes. Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
12. Golden Nugget strain—Con.																							
Cull fruits—																							
1912																							
1913																							
1914	17 3	47																					
1915	158- 6	506																					
Average	**87.8**	**277**																					
Total crop—																							
1912																							
1913																							
1914	260- 0	552	2- 4	10	9- 6	30	22- 6	61	27- 1	65	49-10	126	56-15	104	42-12	67	13-11	14	14- 5	18	4- 7	5	21
1915	407- 5	1,015	1- 0	5	4-12	16	14- 6	43	21- 5	55	47-14	111	51- 4	104	58-14	104	17- 4	27	20- 4	29	12- 0	15	52
Average	**333.7**	**784**	**1.6**	**7**	**7.1**	**23**	**18.4**	**52**	**24.2**	**60**	**48.8**	**118**	**54.1**	**104**	**50.8**	**86**	**15.5**	**23**	**17.3**	**24**	**8.2**	**10**	**37**
13. Washington strain:																							
Orchard grade—																							
1912	308- 6	749	9- 8	36	29- 3	93	31- 0	88	78 12	200	71- 4	161	57- 8	117	6- 5	12	19-12	34	4- 7	7	0-11	1	....
1913	115 10	195	0- 0	0	0-15	3	3-12	10	3-12	9	10- 1	21	17 14	33	39- 8	64	12- 0	18	15 10	22	12- 2	15	....
1914	210- 5	400	0- 0	0	1- 4	4	10- 2	29	20- 8	51	53-13	115	42-15	80	38-12	63	22-10	32	12-12	17	·7- 9	9	....
1915	346-10	731	0-11	3	3- 7	12	14-13	44	37- 7	98	73- 5	171	85- 7	176	80- 2	145	34- 3	57	11- 5	17	5-14	8	....
Average	**245.2**	**519**	**2.5**	**10**	**8.7**	**28**	**14.9**	**43**	**35.1**	**90**	**52.1**	**117**	**50.9**	**102**	**41.2**	**71**	**22.1**	**35**	**11.0**	**16**	**6.6**	**8**	....
Standard grade—																							
1912	42- 0	127	13- 2	55	5- 1	16	7- 3	20	5-11	14	3-14	9	3- 0	6	0- 9	1	3- 8	6	0- 0	0	0- 0	0	....
1913	58- 0	111	0- 8	2	1- 4	4	3- 4	9	5- 0	11	9- 4	20	15-14	30	10- 2	17	1-14	3	6-14	10	4- 0	5	....
1914	24-12	60	1-13	10	1- 6	4	4-13	13	2- 3	5	6- 4	14	3-10	7	1-11	3	0- 0	0	3- 0	4	0- 0	0	....
1915	37-14	93	2-12	13	1-11	6	6- 3	18	1-14	5	4- 6	11	11- 0	23	6- 3	11	1-13	3	2- 0	3	0- 0	0	....
Average	**40.7**	**98**	**4.5**	**20**	**2.3**	**8**	**5.4**	**15**	**3.7**	**9**	**5.9**	**14**	**8.4**	**17**	**4.6**	**8**	**1.8**	**3**	**3.0**	**4**	**1.0**	**1**	....

Cull fruits—																								
1912	44- 7	167																						
1913	39- 4	89																						
1914	35- 0	111																						
1915	44- 9	134																						
Average	**40.8**	**125**																						
Total crop—																								
1912	394-13	1,043	22-10	91	34- 4	109	38- 3.	108	84- 7	214	75- 2	170	60- 8	123	6-14	13	23- 4	40	4- 7	7	0-11	1	1	
1913	212-14	395	0- 8	2	2- 3	7	7- 0	19	8-12	20	19- 5	41	33-12	63	49-10	81	13-14	21	22- 8	32	16- 2	20	0	
1914	270- 1	571	1-13	10	2-10	8	14-15	42	22-11	56	60- 1	129	46- 9	87	40- 7	66	22-10	32	15-12	21	7- 9	9	11	
1915	429- 1	958	3- 7	16	5- 2	18	21- 0	62	39- 5	103	77-11	182	96- 7	199	86- 5	156	36- 0	60	13- 5	20	5-14	8	7	
Average	**326.7**	**742**	**7.1**	**30**	**11.0**	**36**	**20.3**	**58**	**38.8**	**98**	**58.0**	**131**	**59.3**	**118**	**45.8**	**79**	**23.9**	**38**	**14.0**	**20**	**7.6**	**10**	**5**	
16. Washington strain: Orchard grade—																								
1912	305- 0	614	3-10	14	9-12	30	10- 0	28	46-15	117	36- 2	80	75-14	148	18-11	33	56- 3	93	35- 7	51	12- 6	20	....	
1913	102- 7	254	1- 0	5	4- 2	17	9- 9	34	11- 6	34	20- 2	51	23- 8	53	22-10	44	6- 8	11	2- 2	3	1- 8	2	....	
1914	305- 7	573	2- 8	8	7-10	21	30- 9	72	84-12	176	76- 2	138	69-12	111	29- 8	41	4-10	6	0- 0	0	0- 0	0	....	
1915	265- 5	484	0- 7	2	0- 0	0	3- 8	10	10-11	27	41- 0	89	66-11	129	82- 7	141	26- 1	40	23- 1	32	11- 7	14	....	
Average	**244.5**	**481**	**1.9**	**7**	**5.4**	**17**	**13.4**	**36**	**38.4**	**89**	**43.3**	**90**	**59.0**	**110**	**38.3**	**65**	**23.3**	**38**	**15.2**	**22**	**6.3**	**9**	....	
Standard grade—																								
1912	28- 2	69	2- 3	10	2-14	9	3-12	10	4-12	12	2-11	6	6-11	13	1- 2	2	4- 1	7	0- 0	0	0- 0	0	....	
1913	65- 9	179	2- 6	13	6- 1	24	8-15	30	7-12	23	13- 1	34	14- 8	32	5- 8	11	4-10	8	1-15	3	0-13	1	....	
1914	42- 6	91	1- 4	6	0-10	2	6-12	18	4-12	11	9- 0	19	13-12	26	1-14	3	1- 7	2	2- 2	3	0-13	1	....	
1915	66- 4	118	0- 0	0	0- 4	2	1-14	5	2- 6	6	8- 0	18	22- 5	43	12- 3	21	8- 2	10	11- 2	13	0- 0	0	....	
Average	**50.6**	**114**	**1.5**	**7**	**2.5**	**9**	**5.3**	**16**	**4.9**	**13**	**8.2**	**19**	**14.3**	**29**	**5.2**	**9**	**4.6**	**7**	**3.8**	**5**	**0.4**	**0.5**	....	
Cull fruits—																								
1912	7- 9	20																						
1913	73-13	265																						
1914	5- 1	19																						
1915	14- 2	36																						
Average	**25.1**	**85**																						
Total crop—																								
1912	340-11	703	5-13	24	12-10	39	13-12	38	51-11	129	38-13	86	82- 9	161	19-13	35	60- 4	100	35- 7	51	12- 6	20	1	
1913	241-13	698	3- 6	18	10- 3	41	18- 8	64	19- 2	57	33- 3	85	38- 0	85	28- 2	55	11- 2	19	4- 1	6	2- 5	3	0	
1914	352-14	683	3-12	14	8- 4	23	37- 5	90	89- 8	187	85- 2	157	83- 8	137	31- 6	44	6- 1	8	2- 2	3	0-13	1	12	
1915	345-11	638	0- 7	2	0- 4	2	5- 6	15	13- 1	33	49- 0	107	89- 0	172	94-10	162	34- 3	50	34- 3	45	11- 7	14	7	
Average	**320.3**	**681**	**3.3**	**15**	**7.8**	**26**	**18.7**	**52**	**43.3**	**102**	**51.5**	**109**	**73.3**	**139**	**43.5**	**74**	**27.9**	**44**	**19.0**	**26**	**6.7**	**1.0**	**5**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
18. Washington strain:																							
Orchard grade—																							
1912	308–11	690	5–10	21	12–11	40	18– 2	54	67– 7	170	62– 4	138	84– 0	169	12– 6	23	31–11	55	6– 8	10	8– 0	10	....
1913	165– 1	338	0–12	3	6– 1	19	11– 5	33	12– 8	32	36–15	81	41– 3	79	32– 9	56	14– 2	22	5– 0	7	4–10	6	....
1914	287– 3	640	1–12	7	6– 2	21	27–15	81	57– 3	143	98– 0	218	50– 3	96	27–12	48	7– 4	11	9– 8	13	1– 8	2	....
1915	236– 1	421	0– 0	0	0– 5	1	4– 3	13	9– 1	24	25–14	59	39–14	80	71–12	122	26–12	42	32– 0	46	26– 4	34	....
Average	**249.3**	**522**	**2.0**	**8**	**6.3**	**20**	**15.4**	**45**	**36.5**	**92**	**55.8**	**124**	**53.8**	**106**	**36.1**	**62**	**20.0**	**33**	**13.3**	**19**	**10.1**	**13**	....
Standard grade—																							
1912	30– 4	81	3–11	15	5– 6	17	6– 4	17	3– 9	9	6– 2	13	4– 2	8	0– 0	0	1– 2	2	0– 0	0	0– 0	0	....
1913	43– 5	104	2– 2	9	5– 6	17	6– 8	18	4– 0	10	8– 9	19	8–10	17	6– 2	11	0–10	1	1– 6	2	0– 0	0	....
1914	42–14	123	5– 3	26	8– 0	25	13– 1	36	5– 6	13	5– 0	11	4– 6	9	0– 9	1	0–10	1	0–11	1	0– 0	0	....
1915	39– 8	83	0– 8	2	0–13	3	1– 5	4	2– 6	6	4– 0	10	14– 6	30	6– 8	12	3– 0	6	5–12	9	0–14	1	....
Average	**39.0**	**98**	**2.9**	**13**	**4.9**	**16**	**6.8**	**19**	**3.8**	**10**	**5.9**	**13**	**7.9**	**16**	**3.3**	**6**	**1.3**	**3**	**2.0**	**3**	**0.2**	**0.3**	....
Cull fruits—																							
1912	27–12	86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	24– 8	64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	15–12	73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	15–12	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**20.9**	**66**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	366–11	857	9– 5	36	18– 1	57	24– 6	71	71– 0	179	68– 6	151	88– 2	177	12– 6	23	32–13	57	6– 8	10	8– 0	10	8
1913	232–14	506	2–14	12	11– 7	36	17–13	51	16– 8	42	45– 8	100	49–13	96	38–11	67	14–12	23	6– 6	9	4–10	6	2
1914	345–13	836	6–15	33	14– 2	46	41– 0	117	62– 9	156	103– 0	229	54– 9	105	28– 5	49	7–14	12	10– 3	14	1– 8	2	9
1915	291– 5	544	0– 8	2	1– 2	4	5– 8	17	11– 7	30	29–14	69	54– 4	110	78– 4	134	29–12	48	37–12	55	27– 2	35	3
Average	**309.2**	**686**	**4.9**	**21**	**11.2**	**36**	**22.2**	**64**	**40.4**	**102**	**61.7**	**137**	**61.7**	**122**	**39.4**	**68**	**21.3**	**35**	**15.2**	**22**	**10.3**	**13**	**6**

22. Thomson-Washington strain:																								
Orchard grade—																								
1912	271- 1	817	40- 2	165	51-11	173	45-12	138	76- 1	205	40- 5	98	15- 1	34	1- 8	3	0- 9	1	0- 0	0	0- 0	0	....	
1913	202- 8	530	5-10	23	12- 3	42	42- 4	126	53- 0	141	56-11	132	24- 9	51	8- 3	15	0- 0	0	0- 0	0	0- 0	0	....	
1914	263-14	656	2-10	12	15- 5	48	46-10	136	66- 6	171	86- 2	197	35-14	72	9-11	18	1- 4	2	0- 0	0	0- 0	0	....	
1915	266-14	610	0-14	4	4- 4	16	24- 2	76	31- 4	85	62-11	152	56-15	121	60- 8	114	18- 9	31	5- 6	8	2- 5	3	....	
Average	**251.1**	**653**	**12.3**	**51**	**20.9**	**70**	**39.7**	**119**	**56.7**	**151**	**61.5**	**145**	**33.1**	**70**	**20.0**	**38**	**5.1**	**9**	**1.3**	**2**	**0.6**	**0.8**	....	
Standard grade—																								
1912	12-11	59	7-11	35	2- 2	7	2- 8	7	0- 6	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1913	40-11	127	7- 4	31	7-10	26	11-10	35	5-11	16	5-10	13	2-14	6	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	55-11	164	7- 4	37	8- 6	27	15-14	45	7- 3	18	9- 6	22	4-14	10	2-12	5	0- 0	0	0- 0	0	0- 0	0	....	
1915	42- 7	125	5- 2	25	4- 0	15	7- 4	23	4- 9	13	9-14	24	11- 0	24	0- 0	0	0- 0	0	0-10	1	0- 0	0	....	
Average	**37.9**	**117**	**6.8**	**32**	**5.5**	**19**	**9.3**	**28**	**4.5**	**12**	**6.2**	**15**	**4.7**	**10**	**0.7**	**1**	**0**	**0**	**0.2**	**0.3**	**0**	**0**	....	
Cull fruits—																								
1912	9- 0	39	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1913	14- 2	53	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1914	14- 9	56	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
1915	18-12	51	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Average	**14.1**	**50**	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Total crop—																								
1912	292-12	906	47-13	200	53-13	180	48- 4	145	76- 7	206	40- 5	98	15- 1	34	1- 8	3	0- 9	1	0- 0	0	0- 0	0	4	
1913	257- 5	710	12-14	54	19-13	68	53-14	161	58-11	157	62- 5	145	27- 7	57	8- 3	15	0- 0	0	0- 0	0	0- 0	0	0	
1914	334- 2	876	9-14	49	23-11	75	62- 8	181	73- 9	189	95- 8	219	40-12	82	12- 7	23	1- 4	2	0- 0	0	0- 0	0	2	
1915	328- 1	786	6- 0	29	8- 4	31	31- 6	99	35-13	98	72- 9	176	67-15	145	60- 8	114	18- 9	31	6- 0	9	2- 5	3	16	
Average	**303.1**	**820**	**19.1**	**83**	**26.4**	**89**	**49.0**	**117**	**61.1**	**163**	**67.7**	**160**	**37.8**	**80**	**20.7**	**39**	**5.1**	**9**	**1.5**	**2**	**0.6**	**0.8**	**6**	
24. Washington strain:																								
Orchard grade—																								
1912	291-10	607	3- 8	13	10- 8	33	15- 4	43	42- 1	104	43-14	96	84- 7	165	12- 7	23	61- 5	103	9-14	15	8- 6	12	....	
1913	143- 1	285	1- 0	4	3- 6	11	10- 4	28	14-14	36	27- 4	58	32- 1	61	31-15	55	10- 9	16	7-10	11	4- 2	5	....	
1914	273-10	629	0-10	3	9-10	32	37-10	107	68- 6	168	102- 2	219	35-10	67	16- 4	28	2-11	4	0-11	1	0- 0	0	....	
1915	235- 6	483	0- 0	0	0- 0	0	11- 5	33	19- 8	50	57- 0	130	53- 6	108	60- 0	109	23-15	38	7- 4	11	3- 0	4	....	
Average	**235.9**	**501**	**1.3**	**5**	**5.9**	**19**	**18.6**	**53**	**36.2**	**90**	**57.6**	**126**	**51.4**	**100**	**30.2**	**54**	**24.6**	**40**	**6.4**	**10**	**3.9**	**5**	....	
Standard grade—																								
1912	23-10	61	2- 7	11	3- 3	10	2-12	8	5-10	13	2-10	6	5- 4	10	1- 2	2	0-10	1	0- 0	0	0- 0	0	....	
1913	33- 0	79	2-10	10	4- 2	13	4- 2	11	3-11	9	7- 4	16	5-10	11	2-13	5	0-10	1	0-11	1	1- 7	2	....	
1914	54- 4	165	10- 6	51	5- 8	18	17- 7	48	8- 2	20	9- 3	21	2- 0	4	1-10	3	0- 0	0	0- 0	0	0- 0	0	....	
1915	53- 0	127	2- 5	12	4- 3	14	5- 9	16	4- 5	11	6-13	16	15-10	33	10- 1	18	2-14	5	1- 4	2	0- 0	0	....	
Average	**41.0**	**108**	**4.4**	**21**	**4.3**	**14**	**7.5**	**21**	**5.4**	**13**	**6.5**	**15**	**7.1**	**15**	**3.9**	**7**	**0.8**	**2**	**0.5**	**0.8**	**0.4**	**0.5**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
24 Washington strain—Con. Cull fruits—																							
1912	15- 3	74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	42-14	110	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	24-12	85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	16-15	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**24.9**	**79**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	330- 7	742	5-15	24	13-11	43	18- 0	51	47-11	117	46- 8	102	89-11	175	13- 9	25	61-15	104	9-14	15	8- 6	12	4
1913	218-15	474	3 10	14	7 8	24	14 6	39	18- 9	45	34- 8	74	37 11	72	34 12	60	11- 3	17	8- 5	12	5 9	7	0
1914	352 10	879	11- 0	54	15- 2	50	55- 1	155	76 8	188	111- 5	240	37 10	71	17-14	31	2 11	4	0 11	1	0- 0	0	10
1915	305- 5	657	2- 5	12	4- 3	14	16-14	49	23-13	61	63-13	146	69- 0	141	70- 1	127	26-13	43	8- 8	13	3- 0	4	4
Average	**301.8**	**688**	**5.7**	**26**	**10.1**	**33**	**26.1**	**74**	**41.6**	**103**	**61.0**	**141**	**58.5**	**115**	**34.1**	**61**	**25.7**	**42**	**6.8**	**10**	**4.2**	**6**	**5**
25. Washington strain: Orchard grade—																							
1912	280- 5	561	4- 3	16	20- 3	62	30-14	85	76- 2	187	52-11	116	71- 2	141	12- 7	22	11- 7	20	1- 4	2	0- 0	0	....
1913	125-13	244	0- 4	1	2-11	8	7-15	20	11- 5	26	30-14	65	24- 5	46	31-12	54	8- 9	13	5-13	8	2- 5	3	....
1914	165- 2	352	0- 0	0	3 15	13	15 14	44	28-15	71	57 11	121	34 0	63	20 3	34	2- 2	3	0-11	1	1-11	2	....
1915	274 15	580	0 3	1	5 3	18	19- 4	57	32- 1	83	63- 9	144	52-10	106	61-11	110	18- 1	29	17-15	26	4 6	6	....
Average	**211.5**	**457**	**1.2**	**5**	**8.0**	**25**	**18.5**	**52**	**37.1**	**92**	**51.2**	**112**	**45.5**	**89**	**31.5**	**55**	**10.0**	**16**	**6.4**	**9**	**2.1**	**3**	....
Standard grade—																							
1912	39- 6	110	8- 2	32	5-15	18	9-10	26	8-10	20	3- 7	7	3- 1	6	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1913	32 6	67	0 13	3	1 10	5	3- 6	9	3-15	9	5- 6	12	7-12	15	3-10	6	1- 5	2	2- 0	3	2- 9	3	....
1914	37 13	96	2 14	13	4- 2	13	9- 3	25	5 8	13	7 8	16	5- 0	10	3- 0	6	0- 0	0	0- 0	0	0- 0	0	....
1915	23- 8	60	1- 5	6	2- 6	8	3- 1	9	4-12	12	3- 6	8	7- 7	15	0- 9	1	0-10	1	0- 0	0	0- 0	0	....
Average	**33.3**	**83**	**3.3**	**14**	**3.5**	**11**	**6.3**	**17**	**5.7**	**14**	**4.9**	**11**	**5.8**	**12**	**2.1**	**4**	**0.5**	**0.8**	**0.5**	**1**	**0.6**	**0.8**	....

Average	**44.7**	**136**																					
Total crop—																							
1912	365–14	918	12– 5	48	26– 2	80	40– 8	111	84–12	207	56– 2	123	74– 3	147	13– 0	23	11– 7	20	1– 4	2	0– 0	0	0
1913	207– 3	413	1– 1	4	4– 5	13	11– 5	29	15– 4	35	36– 4	77	32– 1	61	35– 6	60	9–14	15	7–13	11	4–14	6	0
1914	243– 5	583	2–14	13	8– 1	26	25– 1	69	34– 7	84	65– 3	137	39– 0	73	23–13	40	2– 2	3	0–11	1	1 11	2	10
1915	341 13	770	1– 8	7	7– 9	26	22– 5	66	36– 3	95	66–15	152	60– 1	121	62– 4	111	18–11	30	17–15	26	4– 6	6	1
Average	**289.5**	**676**	**4.4**	**18**	**11.5**	**36**	**24.8**	**69**	**42.8**	**105**	**56.1**	**122**	**51.3**	**101**	**33.6**	**59**	**10.5**	**17**	**6.9**	**10**	**2.7**	**4**	**3**
26. Thomson strain:																							
Orchard grade—																							
1912	232– 6	602	9– 9	37	32–11	105	26–10	78	64–10	170	45–14	106	39–10	82	4–12	9	8– 0	14	0–10	1	0– 0	0	....
1913	146– 0	372	5– 4	14	14– 6	43	40– 4	115	34– 2	90	36– 2	80	11–12	23	2–14	5	1– 4	2	0– 0	0	0– 0	0	....
1914	273– 1	696	6– 4	32	20– 8	69	53–10	154	77– 8	195	81– 5	180	28– 4	56	5–10	10	0– 0	0	0– 0	0	0– 0	0	....
1915	219– 0	488	0–14	4	7– 2	26	19–15	61	27– 8	73	41– 9	96	45– 0	93	52– 0	96	18– 0	29	5– 8	8	1– 8	2	....
Average	**217.6**	**540**	**5.5**	**22**	**18.7**	**61**	**35.1**	**102**	**50.9**	**132**	**51.2**	**116**	**31.2**	**64**	**16.3**	**30**	**6.8**	**11**	**1.5**	**2**	**0.4**	**0.5**	....
Standard grade—																							
1912	22– 7	72	7– 7	33	3– 6	10	4– 4	12	3– 9	9	0–14	2	2– 6	5	0– 9	1	0– 0	0	0– 0	0	0– 0	0	....
1913	65– 4	207	15–11	66	20–14	68	14– 0	39	6–10	17	4– 7	10	2– 0	4	1–10	3	0– 0	0	0– 0	0	0– 0	0	....
1914	26– 6	74	2–14	14	3– 8	11	7– 6	20	3–14	10	4– 7	10	3–12	8	0– 0	0	0– 9	1	0– 0	0	0– 0	0	....
1915	68– 0	188	5–14	27	6– 2	22	12– 2	37	5– 0	14	20– 6	50	13–10	29	3– 2	6	1– 2	2	0–10	1	0– 0	0	....
Average	**45.5**	**135**	**8.0**	**35**	**8.5**	**28**	**9.4**	**27**	**4.8**	**13**	**7.5**	**18**	**5.4**	**12**	**1.3**	**3**	**0.4**	**0.8**	**0.2**	**0.3**	**0**	**0**	....
Cull fruits—																							
1912	7–15	29																					
1913	35– 0	130																					
1914	12– 7	54																					
1915	42– 8	104																					
Average	**24.5**	**79**																					
Total crop—																							
1912	262–12	703	17– 0	70	36– 1	115	30–14	90	68– 3	179	46–12	108	42– 0	87	5– 5	10	8– 0	14	0–10	1	0– 0	0	3
1913	246– 4	709	20–15	80	35– 4	111	54– 4	154	40–12	107	40– 9	90	13–12	27	4– 8	8	1– 4	2	0– 0	0	0– 0	0	24
1914	311–14	824	9– 2	46	24– 0	80	61– 0	174	81– 6	205	85–12	190	32– 0	64	5–10	10	0– 9	1	0– 0	0	0– 0	0	17
1915	329– 8	780	6–12	31	13– 4	48	32– 1	98	32– 8	87	61–15	146	58–10	122	55– 2	102	19– 2	31	6– 2	9	1– 8	2	55
Average	**287.6**	**754**	**13.5**	**57**	**27.1**	**89**	**44.5**	**129**	**55.7**	**145**	**58.8**	**134**	**36.6**	**75**	**17.6**	**33**	**7.2**	**12**	**1.7**	**3**	**0.4**	**0.5**	**25**

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
34. Washington strain:																							
Orchard grade—																							
1912	242- 2	612	11-10	44	24- 0	76	14-14	57	56- 4	146	57- 8	134	57- 5	118	6- 7	12	14- 2	25	0- 0	0	0- 0	0	....
1913	183- 0	477	1- 9	7	12- 4	43	39- 2	117	54- 7	142	59- 2	135	13-12	28	2-12	5	0- 0	0	0- 0	0	0- 0	0	....
1914	245-14	459	1- 8	5	7- 3	20	17-15	44	59- 6	125	58-12	108	71- 8	115	21- 7	31	8- 3	11	0- 0	0	0- 0	0	....
1915	278-10	515	0- 0	0	1- 6	5	4- 8	14	10-10	28	31-10	74	50- 0	104	64-14	118	53- 4	86	40- 2	59	22- 4	27	....
Average	**237.4**	**516**	**3.7**	**14**	**11.2**	**36**	**19.1**	**58**	**45.2**	**110**	**51.8**	**113**	**48.1**	**91**	**23.9**	**42**	**18.9**	**31**	**10.0**	**15**	**5.6**	**7**	....
Standard grade—																							
1912	13-10	43	4- 0	17	1-14	6	3- 8	10	2-12	7	0- 7	1	0- 8	1	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1913	37- 8	116	7- 6	32	7- 8	25	11-12	34	3- 2	8	5-12	13	2- 0	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	42- 4	89	1-13	9	1-14	6	4- 6	11	2-11	6	5- 8	12	9- 7	18	9-13	17	5- 3	8	1- 9	2	0- 0	0	....
1915	29-10	66	1-10	8	1- 6	5	1-11	5	1- 2	3	2- 8	6	7- 2	15	7- 1	13	5- 0	8	1- 6	2	0-12	1	....
Average	**30.8**	**79**	**3.7**	**17**	**3.2**	**11**	**5.3**	**15**	**2.4**	**6**	**3.5**	**8**	**4.8**	**10**	**4.4**	**8**	**2.5**	**4**	**0.7**	**1**	**0.2**	**0.3**	....
Cull fruits—																							
1912	5- 8	20																					
1913	14- 2	48																					
1914	9- 4	34																					
1915	21- 6	46																					
Average	**12.6**	**37**																					
Total crop—																							
1912	261- 4	675	15-10	61	25-14	82	18- 6	67	59- 0	153	57-15	135	57-13	119	7- 0	13	14- 2	25	0- 0	0	0- 0	0	1
1913	234-10	641	8-15	39	19-12	68	50-14	151	57- 9	150	64-14	148	15-12	32	2-12	5	0- 0	0	0- 0	0	0- 0	0	3
1914	297- 6	582	3- 5	14	9- 1	26	22- 5	55	62- 1	131	64- 4	120	80-15	133	31- 4	48	13- 6	19	1- 9	2	0- 0	0	4
1915	329-10	627	1-10	8	2-12	10	6- 3	19	11-12	31	34- 2	80	57- 2	119	71-15	131	58- 4	94	41- 8	61	23- 0	28	8
Average	**280.7**	**631**	**7.4**	**31**	**14.4**	**47**	**24.4**	**73**	**47.6**	**116**	**55.3**	**121**	**52.9**	**101**	**28.2**	**49**	**21.4**	**35**	**10.8**	**16**	**5.8**	**7**	**4**

54. Thomson strain:																								
Orchard grade																								
1912	207–13	681	53–14	226	64– 2	213	31– 7	92	44–12	119	9– 4	22	3–13	8	0– 0	0	0– 9	1	0– 0	0	0– 0	0	....	
1913	167–11	417	1– 9	7	10– 8	37	32–15	98	37– 8	96	51– 2	114	21– 5	42	12–12	23	0– 0	0	0– 0	0	0– 0	0	....	
1914	248– 5	650	9–14	42	22–10	76	56–11	164	71–12	182	61– 1	136	19– 8	38	6– 2	11	0–11	1	0– 0	0	0– 0	0	....	
1915	285–14	776	8–13	39	22–13	84	63– 4	198	57– 8	158	68– 0	166	35– 8	75	25– 7	49	1–12	3	2– 1	3	0–12	1	....	
Average	**227.4**	**631**	**18.5**	**79**	**30.0**	**103**	**46.1**	**138**	**52.9**	**139**	**47.4**	**110**	**20.0**	**41**	**11.1**	**21**	**0.8**	**1**	**0.5**	**0.8**	**0.2**	**0.3**	....	
Standard grade—																								
1912	15– 3	57	10– 5	43	2– 2	7	0– 6	1	2– 6	6	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1913	32– 7	96	4–14	22	5–11	19	7– 6	21	3– 2	9	8– 4	19	2– 0	4	1– 2	2	0– 0	0	0– 0	0	0– 0	0	....	
1914	31– 0	98	7–15	34	7–14	26	6– 2	17	2– 6	6	4– 4	10	1–15	4	0– 0	0	0– 8	1	0– 0	0	0– 0	0	....	
1915	38–15	127	7– 8	39	7– 0	23	9–12	30	4– 4	12	3–10	9	4– 2	9	2– 2	4	0– 9	1	0– 0	0	0– 0	0	....	
Average	**29.4**	**95**	**7.7**	**35**	**5.7**	**19**	**5.9**	**17**	**3.0**	**8**	**4.0**	**10**	**2.0**	**4**	**0.8**	**2**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	....	
Cull fruits—																								
1912	9– 8	38																						
1913	14– 6	47																						
1914	18–13	82																						
1915	16– 0	47																						
Average	**14.7**	**54**																						
Total crop—																								
1912	232– 8	776	64– 3	269	66– 4	220	31–13	93	47– 2	125	9– 4	22	3–13	8	0– 0	0	0– 9	1	0– 0	0	0– 0	0	5	
1913	214– 8	560	6– 7	29	16– 3	56	40– 5	119	40–10	105	59– 6	133	23– 5	46	13–14	25	0– 0	0	0– 0	0	0– 0	0	8	
1914	298– 2	830	17–13	76	30– 8	102	62–13	181	74– 2	188	65– 5	146	21– 7	42	6– 2	11	1– 3	2	0– 0	0	0– 0	0	8	
1915	340–13	950	16– 5	78	29–13	107	73– 0	228	61–12	170	71–10	175	39–10	84	27– 9	53	2– 5	4	2– 1	3	0–12	1	24	
Average	**271.5**	**779**	**26.2**	**113**	**35.7**	**121**	**52.0**	**155**	**55.9**	**147**	**51.4**	**119**	**22.0**	**45**	**11.9**	**22**	**1.0**	**2**	**0.5**	**0.8**	**0.2**	**0.3**	**11**	
57. Washington strain:																								
Orchard grade—																								
1912	231–10	623	22– 5	89	39–12	126	19– 7	57	58–12	155	41– 5	96	35– 7	74	4– 4	8	9–12	17	0–10	1	0– 0	0	....	
1913	184–13	497	7– 8	32	16– 5	57	47– 6	141	50– 2	130	41–15	95	15–10	32	5– 3	9	0– 0	0	0– 0	0	0–12	1	....	
1914	238– 1	502	1– 4	5	3– 8	11	15– 0	42	38–12	95	83–14	179	59– 2	111	32– 5	53	3– 8	5	0–12	1	0– 0	0	....	
1915	250–12	470	0– 0	0	1– 2	4	5– 4	16	11–14	32	31–12	73	46– 8	96	67– 0	122	34– 4	55	27– 2	40	25–14	32	....	
Average	**226.3**	**523**	**7.8**	**32**	**15.2**	**50**	**21.8**	**64**	**39.9**	**103**	**49.7**	**111**	**39.2**	**78**	**27.2**	**48**	**11.9**	**19**	**7.1**	**11**	**6.7**	**8**	....	
Standard grade—																								
1912	13– 0	44	4– 0	19	3– 8	11	1–14	5	2–12	7	0–14	2	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1913	23–13	78	5–12	26	6– 7	22	5– 6	15	3– 6	9	0–14	2	2– 0	4	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1914	53–12	129	2–12	13	4–13	15	13–14	38	3–13	9	8–11	19	10–12	20	6– 7	11	2–10	4	0– 0	0	0– 0	0	....	
1915	35–15	84	1– 4	6	1– 2	4	4–10	14	1– 8	4	7–10	19	9–11	20	4– 6	8	4– 6	7	1– 6	2	0– 0	0	....	
Average	**31.6**	**84**	**3.4**	**16**	**4.0**	**13**	**6.4**	**18**	**2.9**	**7**	**4.5**	**11**	**5.6**	**11**	**2.7**	**5**	**1.8**	**3**	**0.3**	**0.5**	**0**	**0**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
57. Washington strain—Con.																							
Cull fruits—																							
1912	3-8	16																					....
1913	13-5	49																					....
1914	17-7	72																					....
1915	13-10	28																					....
Average	**12.0**	**41**																					....
Total crop—																							
1912	248-2	683	26-5	108	43-4	137	21-5	62	61-8	162	12-3	28	35-7	74	4-4	8	9-12	17	0-10	1	0-0	0	2
1913	221-15	621	13-4	58	22-12	79	52-12	156	53-8	139	42-13	97	17-10	36	5-3	9	0-0	0	0-0	0	0-12	1	1
1914	30-0 4	703	4-6	18	8-5	26	28-14	80	42-9	104	92-9	198	69-14	131	38-12	61	6-2	9	0-12	1	0-0	0	4
1915	300-5	582	1-4	6	2-4	8	9-14	30	13-6	36	33-6	92	56-3	116	71-6	130	38-10	62	28-8	42	25-14	32	5
Average	**269.9**	**648**	**11.2**	**48**	**19.1**	**63**	**28.2**	**82**	**42.7**	**110**	**51.2**	**121**	**41.8**	**89**	**29.9**	**53**	**13.6**	**22**	**7.5**	**11**	**6.7**	**8**	**3**
66. Yellow Thomson strain:																							
Orchard grade—																							
1912																							
1913	141-12	480	33-10	150	31-9	114	43-0	130	22-14	61	9-12	23	0-15	2	0-0	0	0-0	0	0-0	0	0-0	0	....
1914	202-3	626	24-4	113	42-12	150	54-2	163	43-8	117	27-12	64	8-1	16	1-12	3	0-0	0	0-0	0	0-0	0	....
1915	177-11	552	17-2	74	37-14	138	52-5	164	28-7	80	31-11	74	7-11	17	2-9	5	0-0	0	0-0	0	0-0	0	....
Average	**173.9**	**553**	**25.0**	**112**	**37.4**	**134**	**49.8**	**152**	**31.6**	**86**	**23.1**	**54**	**5.6**	**12**	**1.4**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	....
Standard grade—																							
1912																							....
1913	51-5	183	18-15	87	14-9	48	8-12	25	5-3	14	3-14	9	0-0	0	0-0	0	0-0	0	0-0	0	0-0	0	....
1914	37-11	128	7-12	40	10-4	35	11-6	33	3-0	8	2-14	7	1-7	3	1-0	2	0-0	0	0-0	0	0-0	0	....
1915	53-11	206	21-8	100	14-6	54	10-2	32	3-7	10	3-3	8	0-8	1	0-9	1	0-0	0	0-0	0	0-0	0	....
Average	**47.6**	**172**	**16.1**	**76**	**13.1**	**46**	**10.1**	**30**	**3.9**	**11**	**3.3**	**8**	**0.6**	**1**	**0.5**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	....

Cull fruits—																								
1912																								
1913	19- 2	84																						
1914	32- 9	140																						
1915	76-15	340																						
Average	**42.9**	**188**																						
Total crop—																								
1912																								
1913	212- 3	747	52- 9	237	46- 2	162	51-12	155	28- 1	75	13-10	32	0-15	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0		
1914	272- 7	894	32- 0	153	53- 0	185	65- 8	196	46- 8	125	30-10	71	9- 8	19	2-12	5	0- 0	0	0- 0	0	0- 0	0	7	
1915	308- 5	1,098	38-10	174	52- 4	192	62- 7	196	31-14	90	34-14	82	8- 3	18	3- 2	6	0- 0	0	0- 0	0	0- 0	0	24	
Average	**264.3**	**913**	**41.1**	**188**	**50.5**	**180**	**59.9**	**182**	**35.5**	**97**	**26.4**	**62**	**6.2**	**13**	**2.0**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**14**	
73. Washington strain:																								
Orchard grade—																								
1912	246-10	538	4- 0	15	14-11	47	11- 4	33	42- 0	109	53- 4	122	63- 6	129	12- 1	22	37- 6	48	8-10	13	0- 0	0		
1913	174-12	406	2-14	11	11- 5	39	29-13	84	26- 0	66	42- 1	92	33- 3	65	22-11	39	3- 5	5	2-12	4	0-12	1		
1914	199- 2	429	1-10	7	2-10	9	25-10	72	40- 7	98	58-14	124	38-10	71	23- 3	38	1- 6	2	3-14	5	2-14	3		
1915	169-11	343	0- 0	0	0-13	3	4-10	14	11-13	31	37- 6	85	42-14	88	43- 8	78	18-14	30	7- 8	11	2- 5	3		
Average	**197.5**	**429**	**2.1**	**8**	**7.4**	**25**	**17.8**	**51**	**30.1**	**76**	**47.9**	**106**	**44.5**	**88**	**25.4**	**44**	**15.2**	**21**	**5.7**	**8**	**1.5**	**2**		
Standard grade—																								
1912	41- 3	108	3-14	17	5- 0	16	6-12	19	10- 7	26	4- 1	9	8- 3	16	2-14	5	0- 0	0	0- 0	0	0- 0	0		
1913	22-13	66	4- 7	18	5- 3	17	3- 9	10	2- 2	5	4- 6	10	2- 1	4	1- 1	2	0- 0	0	0- 0	0	0- 0	0		
1914	50- 3	108	3- 4	17	3- 5	11	4- 5	12	2-14	7	6- 1	13	9-15	19	6-12	11	4- 1	6	4- 8	6	5- 2	6		
1915	32- 7	73	0- 6	2	1- 2	4	2- 1	6	1-14	5	8- 8	20	12- 8	26	2- 1	4	1-15	3	1- 4	2	0-12	1		
Average	**36.7**	**89**	**3.0**	**14**	**3.7**	**12**	**4.2**	**12**	**4.3**	**11**	**5.8**	**13**	**8.2**	**16**	**3.2**	**6**	**1.5**	**2**	**1.4**	**2**	**1.5**	**2**		
Cull fruits—																								
1912	42-11	139																						
1913	34- 0	100																						
1914	4- 1	22																						
1915	22-12	56																						
Average	**25.9**	**79**																						
Total crop—																								
1912	330- 8	785	7-14	32	19-11	63	18- 0	52	52- 7	135	57- 5	131	71- 9	145	14-15	27	37- 6	48	8-10	13	0- 0	0	1	
1913	231- 9	572	7- 5	29	16- 8	56	33- 6	94	28- 2	71	46- 7	102	35- 4	69	23-12	41	3- 5	5	2-12	4	0-12	1	3	
1914	253- 6	559	4-14	24	5-15	20	29-15	84	43- 5	105	64-15	137	48- 9	90	29-15	49	5- 7	8	8- 6	11	8- 0	9	14	
1915	224-14	472	0- 6	2	1-15	7	6-11	20	13-11	36	45-14	105	55- 6	114	45- 9	82	20-13	33	8-12	13	3- 1	4	2	
Average	**260.1**	**597**	**5.1**	**22**	**11.0**	**37**	**22.0**	**63**	**34.4**	**87**	**53.6**	**119**	**52.7**	**105**	**28.5**	**50**	**16.7**	**24**	**7.1**	**10**	**3.0**	**4**	**5**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
95. Thomson strain:																							
Orchard grade—																							
1912	212–13	678	47– 6	188	65– 8	218	34– 8	103	45– 9	122	17– 2	41	2–12	6	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	154– 3	449	13–10	60	22–10	82	37– 5	113	29–12	81	35–10	83	10– 2	21	2–10	5	2– 8	4	0– 0	0	0– 0	0	....
1914	245– 7	672	11–11	50	30– 4	103	64–12	190	65– 6	168	54– 3	123	16–10	34	1– 3	2	1– 6	2	0– 0	0	0– 0	0	....
1915	234– 1	587	1– 2	5	8– 8	31	27 14	89	50– 4	139	65– 2	160	39– 2	85	31– 8	61	6– 8	11	2– 9	4	1– 8	2	....
Average	**211.6**	**597**	**18.5**	**76**	**31.7**	**109**	**41.1**	**124**	**47.7**	**127**	**43.0**	**102**	**17.2**	**37**	**8.8**	**17**	**2.6**	**4**	**0.6**	**1**	**0.4**	**0.5**	....
Standard grade—																							
1912	30–10	134	20– 0	101	2–14	11	4– 6	13	2– 8	7	0–14	2	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	19– 1	68	6– 4	32	3– 2	11	6– 1	17	1– 2	3	0–14	2	0– 8	1	1– 2	2	0– 0	0	0– 0	0	0– 0	0	....
1914	17–14	65	5–12	33	1–15	6	7– 7	20	0– 6	1	2– 6	5	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1915	49– 8	149	6– 7	30	3–11	14	15– 3	46	4–13	14	10– 6	27	5–11	12	2– 1	4	0–10	1	0–10	1	0– 0	0	....
Average	**29.3**	**104**	**9.6**	**49**	**2.9**	**11**	**8.3**	**24**	**2.2**	**6**	**3.6**	**9**	**1.5**	**3**	**0.8**	**2**	**0.2**	**0.3**	**0.2**	**0.3**	**0**	**0**	....
Cull fruits—																							
1912	10– 6	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	17– 1	79	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	4– 0	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	9– 8	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**10.2**	**43**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	253–13	860	67– 6	289	68– 6	229	38–14	116	48– 1	129	18– 0	43	2–12	6	0– 0	0	0– 0	0	0– 0	0	0– 0	0	7
1913	190– 5	596	19–14	92	25–12	93	43– 6	130	30–14	84	36– 8	85	10–10	22	3–12	7	2– 8	4	0– 0	0	0– 0	0	6
1914	267– 5	751	17– 7	83	32– 3	109	72– 3	210	65–12	169	56– 9	128	16–10	34	1– 3	2	1– 6	2	0– 0	0	0– 0	0	4
1915	293– 1	766	7– 9	35	12– 3	45	43– 1	135	55– 1	153	75– 8	187	44–13	97	33– 9	65	7– 2	12	3– 3	5	1– 8	2	18
Average	**251.1**	**743**	**28.1**	**125**	**34.6**	**119**	**49.4**	**148**	**49.9**	**134**	**46.6**	**111**	**18.7**	**40**	**9.6**	**19**	**2.8**	**5**	**0.8**	**1**	**0.4**	**0.5**	**9**

97. Washington strain:																								
Orchard grade—																								
1912	199- 9	550	23- 0	90	34-12	112	20- 2	58	53- 6	140	31- 7	74	31- 4	66	1- 2	2	4- 8	8	0- 0	0	0- 0	0	....	
1913	136-11	362	2-11	12	9- 5	34	30- 4	94	28- 5	76	38- 8	90	20-10	43	7- 0	13	0- 0	0	0- 0	0	0- 0	0	....	
1914	194- 3	420	0- 9	2	4- 8	15	14- 4	41	29-10	74	58- 7	130	49-10	96	34- 7	58	2- 0	3	0-12	1	0- 0	0	....	
1915	224- 5	417	0- 0	0	0- 8	2	2-11	8	10- 0	27	21- 2	51	34- 2	72	62-12	117	36-11	60	32- 4	49	24- 3	31	....	
Average	**188.7**	**437**	**6.6**	**26**	**12.3**	**41**	**16.8**	**50**	**30.3**	**79**	**37.4**	**86**	**33.9**	**69**	**26.3**	**48**	**10.8**	**18**	**8.3**	**13**	**6.0**	**8**	....	
Standard grade—																								
1912	17- 7	64	7- 4	36	4- 2	13	2- 0	6	2- 0	5	0- 7	1	1- 1	2	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1913	44- 7	128	5- 6	22	6- 6	22	9-10	29	7- 1	19	8-10	21	5-12	12	1-10	3	0- 0	0	0- 0	0	0- 0	0	....	
1914	80-11	203	6- 6	29	10- 1	33	12-14	35	7- 4	18	17- 2	39	12- 1	24	10-13	19	2-10	4	0- 0	0	1- 8	2	....	
1915	44-14	106	2- 0	10	1- 5	5	2- 7	8	4- 5	12	7- 3	18	12- 6	27	7- 2	13	3- 8	6	3- 4	5	1- 6	2	....	
Average	**46.9**	**125**	**5.3**	**24**	**5.5**	**18**	**6.7**	**20**	**5.2**	**14**	**8.3**	**20**	**7.8**	**16**	**5.0**	**9**	**1.5**	**3**	**0.8**	**1**	**0.7**	**1**	....	
Cull fruits—																								
1912	9- 7	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1913	14-14	51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1914	11- 4	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
1915	20-14	53	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
Average	**14.1**	**45**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	
Total crop—																								
1912	226- 7	646	30- 4	126	38-14	125	22- 2	64	55- 6	145	31-14	75	32- 5	68	1-11	3	4- 8	8	0- 0	0	0- 0	0	6	
1913	196- 0	541	8- 1	34	15-11	56	39-14	123	35- 6	95	47- 2	111	26- 6	55	8-10	16	0- 0	0	0- 0	0	0- 0	0	3	
1914	286- 2	668	6-15	31	14- 9	48	27- 2	76	36-14	92	75- 9	169	61-11	120	45- 4	77	4-10	7	0-12	1	1- 8	2	7	
1915	290- 1	576	2- 0	10	1-13	7	5- 2	16	14- 5	39	28- 5	69	46- 8	99	69-14	130	40- 3	66	35- 8	54	25- 9	33	9	
Average	**249.7**	**608**	**11.8**	**50**	**17.7**	**59**	**23.6**	**70**	**35.5**	**93**	**45.7**	**106**	**41.7**	**86**	**31.4**	**57**	**12.3**	**20**	**9.1**	**14**	**6.8**	**9**	**6**	
108. Sporting Thomson strain:																								
Orchard grade—																								
1912	157- 3	524	46- 0	197	40- 9	137	25- 6	75	26-11	72	12- 0	29	5-15	13	0- 0	0	0-10	1	0- 0	0	0- 0	0	....	
1913	152- 2	453	10-10	47	29- 6	105	47- 0	140	37-80	98	23- 1	54	4- 0	8	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1914	220- 6	554	7- 1	28	15- 6	52	47- 0	134	58-10	147	60- 7	133	23-14	47	5-14	10	2- 2	3	0- 0	0	0- 0	0	....	
1915	223- 9	626	7- 2	33	30- 2	110	46-13	147	51-14	144	39- 4	95	27-10	59	16- 2	31	1- 2	2	2- 0	3	1- 8	2	....	
Average	**188.3**	**539**	**17.7**	**76**	**28.9**	**101**	**41.5**	**124**	**43.7**	**115**	**33.7**	**78**	**15.4**	**32**	**5.6**	**11**	**1.0**	**2**	**0.5**	**0.8**	**0.4**	**0.5**	....	
Standard grade—																								
1912	26- 8	96	11-10	53	6- 1	20	4- 8	13	2- 6	6	1- 7	3	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1913	28- 1	92	6- 0	27	7- 6	25	7-14	23	3- 7	9	2- 6	6	1- 0	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	54-14	155	8- 8	40	7-11	24	14- 1	38	6- 8	16	8- 2	18	8- 4	16	1- 2	2	0-10	1	0- 0	0	0- 0	0	....	
1915	58- 5	199	13- 7	64	12- 8	45	13- 4	42	6- 7	18	7- 8	19	3-10	8	1- 9	3	0- 0	0	0- 0	0	0- 0	0	....	
Average	**41.9**	**136**	**9.9**	**46**	**8.4**	**29**	**9.9**	**29**	**4.7**	**12**	**4.9**	**12**	**3.3**	**7**	**0.7**	**1**	**0.2**	**0.3**	**.0**	**0**	**0**	**0**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																					
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
108. Sporting Thomson strain—Continued.																							
Cull fruits—																							
1912	16–10	64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	16– 4	65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	10– 3	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	15–13	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**14.7**	**55**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	200– 5	684	57–10	250	46–10	157	29–14	88	29– 1	78	13– 7	32	6– 7	14	0– 0	0	0–10	1	0– 0	0	0– 0	0	25
1913	196– 7	610	16–10	74	36–12	130	54–14	163	40–15	107	25– 7	60	5– 0	10	0– 9	1	0– 0	0	0– 0	0	0– 0	0	33
1914	285– 7	754	15– 9	68	23– 1	76	61– 1	172	65 2	163	68– 9	151	32– 2	63	7– 0	12	2–12	4	0– 0	0	0– 0	0	54
1915	297–11	871	20– 9	97	42–10	155	60– 1	189	58– 5	162	46–12	114	31– 4	67	17–11	34	1– 2	2	2– 0	3	1– 8	2	63
Average	**245.0**	**730**	**27.6**	**122**	**37.3**	**130**	**51.5**	**153**	**48.4**	**128**	**38.5**	**89**	**18.7**	**39**	**6.3**	**12**	**1.1**	**2**	**0.5**	**0.8**	**0.4**	**0.5**	**44**
123. Washington strain:																							
Orchard grade—																							
1912	194– 5	424	3–10	14	9– 6	29	8– 6	24	27– 2	70	29– 3	67	55–10	115	14–13	28	35– 4	61	5–13	9	5– 2	7	.....
1913	152–13	361	2– 5	9	6–11	23	21– 2	62	29– 6	75	42–10	97	29–12	59	15– 0	27	3– 3	5	2–12	4	0– 0	0	.....
1914	178– 2	349	0– 0	0	1– 3	4	12– 1	34	19– 5	47	46– 1	96	46–10	85	38–13	63	10–14	16	1– 8	2	1–11	2	.....
1915	214– 1	411	0– 0	0	0– 0	0	7– 4	22	8– 8	23	29 15	70	43– 4	89	60– 2	109	28 10	47	23–14	35	12– 8	16	.....
Average	**184.8**	**386**	**1.5**	**6**	**4.3**	**14**	**12.2**	**36**	**21.1**	**54**	**37.0**	**83**	**43.8**	**87**	**32.2**	**57**	**19.5**	**32**	**8.5**	**13**	**4.8**	**6**	.....
Standard grade—																							
1912	15–14	37	1– 7	6	0–11	2	1– 3	3	3–11	9	3– 2	7	2–11	5	1–12	3	1– 5	2	0– 0	0	0– 0	0	.....
1913	21–11	59	2– 4	9	4–14	17	2–10	8	2–11	7	2– 4	5	5– 2	10	1– 3	2	0– 0	0	0–11	1	0– 0	0	.....
1914	47– 0	106	1 14	8	3–10	11	6– 9	17	7– 6	17	10– 8	23	9– 4	18	3– 6	6	2– 1	3	1– 8	2	0–14	1	.....
1915	44– 7	97	0–12	4	0– 5	1	2–14	9	3– 0	8	9– 2	22	12– 2	25	11– 4	21	4– 2	6	0– 0	0	0–14	1	.....
Average	**32.3**	**75**	**1.6**	**7**	**2.4**	**8**	**3.3**	**9**	**4.2**	**10**	**6.3**	**14**	**7.3**	**15**	**4.4**	**8**	**1.9**	**3**	**0.5**	**0.8**	**0.4**	**0.5**	.....

Cull fruits—																								
1912	15–2	45																						
1913	35–4	103																						
1914	11–13	24																						
1915	29–12	60																						
Average	**23.0**	**58**																						
Total crop—																								
1912	225–5	506	5–1	20	10–1	31	9–9	27	30–13	79	32–5	74	58–5	120	16–9	31	36–9	63	5–13	9	5–2	7	2	
1913	209–12	523	4–9	18	11–9	40	23–12	70	32–1	82	44–14	102	34–14	69	16–3	29	3–3	5	3–7	5	0–0	0	0	
1914	236–15	479	1–14	8	4–13	15	18–10	51	26–11	64	56–9	119	55–14	103	42–3	69	12–15	19	3–0	4	2–9	3	5	
1915	288–4	568	0–12	4	0–5	1	10–2	31	11–8	31	39–1	92	55–6	114	71–6	130	32–12	53	23–14	35	13–6	17	6	
Average	**240.1**	**519**	**3.1**	**13**	**6.7**	**22**	**15.5**	**45**	**25.3**	**64**	**43.2**	**97**	**51.1**	**102**	**36.6**	**65**	**21.4**	**35**	**9.0**	**13**	**5.3**	**7**	**3**	
155. Thomson strain:																								
Orchard grade—																								
1912	208–13	687	50–3	209	63–14	216	36–13	111	41–10	112	11–5	28	5–0	11	0–0	0	0–0	0	0–0	0	0–0	0	....	
1913	165–8	423	2–12	11	6–8	22	32–2	98	45–8	119	51–11	119	22–10	46	4–5	8	0–0	0	0–0	0	0–0	0	....	
1914	208–10	556	7–11	35	18–10	64	42–6	124	60–4	156	61–11	141	14–2	29	3–14	7	0–0	0	0–0	0	0–0	0	....	
1915	206–10	482	1–10	7	8–3	30	19–15	61	29–12	80	45–12	109	44–10	95	31–3	59	15–2	25	8–3	13	2–4	3	....	
Average	**197.4**	**537**	**15.6**	**66**	**24.3**	**83**	**32.8**	**99**	**44.3**	**117**	**42.6**	**99**	**21.6**	**45**	**9.8**	**19**	**3.8**	**6**	**2.0**	**3**	**0.6**	**0.8**	....	
Standard grade—																								
1912	12–2	47	6–10	29	4–2	14	1–6	4	0–0	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0	0	....	
1913	22–10	65	2–7	11	5–7	18	3–8	10	3–7	9	5–4	12	2–0	4	0–9	1	0–0	0	0–0	0	0–0	0	....	
1914	17–6	59	4–2	21	4–14	16	2–15	9	2–12	7	2–11	6	0–0	0	0–0	0	0–0	0	0–0	0	0–0	0	....	
1915	47–0	126	3–6	19	3–14	14	7–6	22	4–0	11	9–0	22	13–10	29	2–12	5	0–10	1	0–11	1	1–11	2	....	
Average	**24.8**	**74**	**4.1**	**20**	**4.6**	**16**	**3.8**	**11**	**2.5**	**7**	**4.2**	**10**	**3.9**	**8**	**0.8**	**2**	**0.2**	**0.3**	**0.2**	**0.3**	**0.4**	**0.5**	....	
Cull fruits—																								
1912	5–4	29																						
1913	9–8	36																						
1914	11–8	48																						
1915	7–7	21																						
Average	**8.4**	**34**																						
Total crop—																								
1912	226–3	763	56–13	238	68–0	230	38–3	115	41–10	112	11–5	28	5–0	11	0–0	0	0–0	0	0–0	0	0–0	0	0	
1913	197–10	524	5–3	22	11–15	40	35–10	108	48–15	128	56–15	131	21–10	50	4–14	9	0–0	0	0–0	0	0–0	0	1	
1914	237–8	663	11–13	56	23–8	80	45–5	133	63–0	163	64–6	117	14–2	29	3–14	7	0–0	0	0–0	0	0–0	0	2	
1915	261–1	629	5–0	26	12–1	44	27–5	83	33–12	91	54–12	131	58–4	124	33–15	64	15–12	26	8–14	14	3–15	5	7	
Average	**230.6**	**645**	**19.7**	**86**	**28.9**	**99**	**36.6**	**110**	**46.8**	**124**	**46.8**	**109**	**25.5**	**54**	**10.7**	**20**	**3.9**	**7**	**2.2**	**4**	**1.0**	**1**	**3**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
156. Washington strain:																							
Orchard grade—																							
1912	249- 0	563	5- 6	19	17- 0	52	19-15	54	60- 7	148	56-13	124	57- 6	113	4- 6	8	20- 4	34	7- 7	11	0- 0	0	....
1913	62-15	142	0- 0	0	0- 8	2	2-10	8	10- 4	28	18- 5	44	15-14	33	10- 5	19	3-11	6	0- 0	0	1- 6	2	....
1914	220- 1	438	1- 3	5	5- 0	16	14-12	42	19-15	49	58-10	125	53- 2	99	43- 8	70	15- 2	21	6-15	9	1-14	2	....
1915	162-13	277	0- 0	0	0- 0	0	1- 0	3	4- 4	11	11- 4	25	31- 4	62	46- 9	81	23- 3	35	27- 7	38	17- 4	22	....
Average	**173.7**	**355**	**1.6**	**6**	**5.6**	**18**	**9.6**	**27**	**23.7**	**59**	**36.3**	**80**	**39.4**	**77**	**26.2**	**45**	**15.6**	**24**	**10.5**	**15**	**5.1**	**7**	....
Standard grade—																							
1912	26- 5	74	5- 9	23	3- 5	10	4- 6	12	4-14	12	4-15	11	2- 1	4	0- 0	0	1- 3	2	0- 0	0	0- 0	0	....
1913	20- 4	74	1- 8	6	1- 2	4	5- 4	16	5- 4	14	7- 5	17	4- 4	9	2- 2	4	1- 2	2	0-10	1	0-11	1	....
1914	15-11	35	0- 8	2	0-10	2	3- 0	8	2- 0	5	3- 3	7	2- 7	5	2- 8	4	0- 0	0	1- 7	2	0- 0	0	....
1915	38- 2	73	0- 0	0	0- 0	0	0-10	2	1- 2	3	5-14	14	12- 2	25	7-15	14	3- 3	5	5- 8	8	1-12	2	....
Average	**27.3**	**64**	**1.9**	**8**	**1.3**	**4**	**3.3**	**10**	**3.3**	**9**	**5.3**	**12**	**5.2**	**11**	**3.1**	**6**	**1.4**	**2**	**1.9**	**3**	**0.6**	**0.8**	....
Cull fruits—																							
1912	13- 7	52																					....
1913	76- 9	280																					....
1914	3-13	14																					....
1915	20- 9	56																					....
Average	**28.6**	**101**																					....
Total crop—																							
1912	288-12	689	10-15	42	20- 5	62	24- 5	66	65- 5	160	61-12	135	59- 7	117	4- 6	8	21- 7	36	7- 7	11	0- 0	0	1
1913	168-12	496	1- 8	6	1-10	6	7-14	24	15- 8	42	25-10	61	20- 2	42	12- 7	23	4-13	8	0-10	1	2- 1	3	3
1914	239- 9	487	1-11	7	5-10	18	17-12	50	21-15	54	61-13	132	55- 9	104	46- 0	74	15- 2	21	8- 6	11	1-14	2	8
1915	221- 8	406	0- 0	0	0- 0	0	1-10	5	5- 6	14	17- 2	39	43- 6	87	54- 8	95	26- 6	40	32-15	46	19-10	24	5
Average	**229.6**	**520**	**3.5**	**14**	**6.9**	**22**	**12.9**	**36**	**27.0**	**68**	**41.6**	**92**	**44.6**	**87**	**29.3**	**50**	**16.9**	**26**	**12.3**	**17**	**5.9**	**7**	**4**

185. Washington strain:																								
Orchard grade—																								
1912	203- 3	511	10-12	41	18-12	60	21- 2	61	52- 8	135	46- 9	107	40- 5	83	4-10	9	7- 6	13	1- 3	2	0- 0	0	....	
1913	96- 6	218	2- 8	10	3- 8	12	12-15	38	14- 5	36	19- 5	43	19-12	39	15-10	28	4- 8	7	2- 3	3	1-12	2	....	
1914	164-11	372	0- 7	2	6-10	22	24- 6	71	30- 2	75	46- 4	100	33-13	64	21-12	36	0-10	1	0-11	1	0- 0	0	....	
1915	196- 0	449	0- 7	2	4-14	18	16- 3	49	27- 2	72	49-12	119	44- 0	93	36- 5	68	12-10	21	3- 3	5	1- 8	2	....	
Average	**165.1**	**388**	**3.5**	**14**	**8.4**	**28**	**18.7**	**55**	**31.0**	**80**	**40.5**	**92**	**34.5**	**70**	**19.6**	**35**	**6.3**	**11**	**1.8**	**3**	**0.8**	**1**	....	
Standard grade—																								
1912	25- 0	73	5- 9	23	3- 2	10	4-13	14	5- 5	13	3- 3	7	2- 7	5	0- 0	0	0- 9	1	0- 0	0	0- 0	0	....	
1913	31- 0	81	3- 4	14	4-11	17	3- 8	10	4-15	13	3- 4	7	6- 2	12	2- 7	4	1-15	3	0- 0	0	0-14	1	....	
1914	30-12	90	5- 8	27	2-10	9	8-12	24	3- 6	8	5-14	13	3-15	8	0- 0	0	0- 0	0	0-11	1	0- 0	0	....	
1915	46-10	118	1-10	8	4-10	17	3-14	12	4- 0	11	12-10	31	12- 6	26	4- 6	8	1-12	3	1- 6	2	0- 0	0	....	
Average	**33.3**	**91**	**4.0**	**18**	**3.8**	**13**	**5.2**	**15**	**4.4**	**11**	**6.2**	**15**	**6.2**	**13**	**1.7**	**3**	**1.1**	**2**	**0.5**	**0.8**	**0.2**	**0.3**	....	
Cull fruits—																								
1912	23- 2	89																						
1913	34-13	108																						
1914	5- 4	24																						
1915	23-14	81																						
Average	**21.8**	**76**																						
Total crop—																								
1912	251- 5	673	16- 5	64	21-14	70	25-15	75	57-13	148	49-12	114	42-12	88	4-10	9	7-15	14	1- 3	2	0- 0	0	0	
1913	162- 3	407	5-12	24	8- 3	29	16- 7	48	19- 4	49	22- 9	50	25-14	51	18- 1	32	6- 7	10	2- 3	3	2-10	3	0	
1914	200-11	486	5-15	29	9- 4	31	33- 2	95	33- 8	83	52- 2	113	37-12	72	21-12	36	0-10	1	1- 6	2	0- 0	0	3	
1915	266- 8	648	2- 1	10	9- 8	35	20- 1	61	31- 2	83	62- 6	150	56- 6	119	40-11	76	14- 6	24	4- 9	7	1- 8	2	0	
Average	**220.2**	**554**	**7.5**	**32**	**12.2**	**41**	**23.9**	**70**	**35.4**	**91**	**46.7**	**107**	**40.7**	**83**	**21.3**	**38**	**7.3**	**12**	**2.3**	**4**	**1.0**	**1**	**0.8**	
202. Golden Nugget strain:																								
Orchard grade—																								
1912																								
1913																								
1914	127- 4	248	1- 4	5	5- 2	16	13- 4	37	16-10	39	28-14	61	28-14	42	20-10	32	5-15	8	4- 0	5	2-11	3	....	
1915	144-10	264	0- 0	0	0- 8	2	8-13	26	8- 5	22	19- 6	45	20- 7	42	24- 6	43	15-14	25	14-12	21	32- 2	38	....	
Average	**135.9**	**256**	**0.6**	**3**	**2.8**	**9**	**11.0**	**32**	**12.5**	**31**	**24.1**	**53**	**24.7**	**42**	**22.5**	**38**	**10.9**	**17**	**9.4**	**13**	**17.4**	**21**	....	
Standard grade—																								
1912																								
1913																								
1914	24-11	62	1- 5	6	4- 4	14	5- 2	14	3- 6	8	3-12	8	5- 5	10	0- 0	0	0- 0	0	1- 9	2	0- 0	0	....	
1915	40-13	87	0-11	3	1- 6	5	2-11	8	4-15	13	7- 8	18	8- 1	17	3-14	7	4- 7	7	3-10	5	3-10	4	....	
Average	**32.8**	**75**	**1.0**	**5**	**2.8**	**10**	**3.9**	**11**	**4.2**	**11**	**5.6**	**13**	**6.7**	**11**	**1.9**	**4**	**2.2**	**4**	**2.6**	**4**	**1.8**	**2**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
202. Golden Nugget strain—Continued.																							
Cull fruits—																							
1912																							....
1913																							....
1914	11-11	36																					....
1915	83- 1	236																					....
Average	**47.4**	**136**																					....
Total crop—																							
1912																							....
1913																							....
1914	163-10	346	2- 9	11	9- 6	30	18- 6	51	20- 0	47	32-10	69	34- 3	52	20-10	32	5-15	8	5- 9	7	2-11	3	9
1915	258- 8	587	0-11	3	1-15	7	11- 8	34	13- 4	35	26-14	63	28- 8	59	28- 4	50	20- 5	32	18- 6	26	35-12	42	43
Average	**216.1**	**467**	**1.6**	**7**	**5.7**	**19**	**14.9**	**43**	**16.6**	**41**	**29.8**	**66**	**31.3**	**56**	**24.4**	**41**	**13.1**	**20**	**12.0**	**16**	**19.2**	**23**	**26**
224. Washington strain:																							
Orchard grade—																							
1912	192- 1	429	5- 2	18	12- 2	37	16-11	46	38- 5	94	32- 8	71	55-12	110	4- 7	8	22- 3	38	2-10	4	2- 5	3	....
1913	160- 8	430	7-12	32	14-10	53	38- 6	117	26-10	70	41- 2	96	13- 8	40	11- 4	20	1- 4	2	0- 0	0	0- 0	0	....
1914	228- 7	524	1- 8	6	8- 6	27	31- 2	87	47- 8	119	74-10	164	47- 4	90	16- 2	28	1-15	3	0- 0	0	0- 0	0	....
1915	105- 2	200	0- 0	0	0- 9	2	3- 7	10	5-11	14	18- 1	40	23- 9	47	33- 7	57	13-0	20	5- 0	7	2- 6	3	....
Average	**171.5**	**396**	**3.6**	**14**	**8.9**	**30**	**22.4**	**65**	**29.5**	**74**	**41.6**	**93**	**36.5**	**72**	**16.3**	**28**	**9.6**	**16**	**1.9**	**3**	**1.2**	**2**	....
Standard grade—																							
1912	13- 0	35	2- 0	9	0-15	3	2- 4	6	3- 7	8	1- 5	3	2- 8	5	0- 0	0	0- 9	1	0- 0	0	0- 0	0	....
1913	31- 9	96	3-14	17	8- 4	28	9-12	28	2-10	7	4- 2	10	2- 6	5	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1914	17- 6	57	3-12	20	3-12	12	4- 2	12	2- 6	6	2- 6	5	1- 0	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	37- 2	67	0- 0	0	0- 4	1	0-11	2	1- 4	3	3- 8	8	5- 3	11	11- 0	19	5- 8	9	7- 7	11	2- 5	3	....
Average	**24.8**	**64**	**2.4**	**12**	**3.3**	**11**	**4.2**	**12**	**2.4**	**6**	**2.8**	**7**	**2.8**	**6**	**2.9**	**5**	**1.5**	**3**	**1.9**	**3**	**0.6**	**0.8**	....

Cull fruits—																								
1912	13–12	53																						
1913	17– 9	62																						
1914	13–12	57																						
1915	9– 9	32																						
Average	**13.7**	**51**																						
Total crop—																								
1912	218–13	517	7– 2	27	13– 1	40	18–15	52	41–12	102	33–13	74	58– 4	115	4– 7	8	22–12	39	2–10	4	2– 5	3	2	
1913	209–10	588	11–10	49	22–14	81	48– 2	145	29– 4	77	45– 4	106	21–14	45	11–13	21	1– 4	2	0– 0	0	0– 0	0	0	
1914	259– 9	638	5– 4	26	12– 2	39	35– 4	99	49–14	125	77– 0	169	48– 4	92	16– 2	28	1–15	3	0– 0	0	0– 0	0	6	
1915	151–13	299	0– 0	0	0–13	3	4– 2	12	6–15	17	21– 9	48	28–12	58	44– 7	76	18– 8	29	12– 7	18	4–11	6	3	
Average	**210.0**	**511**	**6.0**	**26**	**12.2**	**41**	**26.6**	**77**	**32.0**	**80**	**4.44**	**99**	**39.3**	**78**	**19.2**	**33**	**11.1**	**18**	**3.8**	**6**	**1.8**	**2**	**3**	
247; Thomson strain: Orchard grade—																								
1912	162–10	603	80– 2	340	50– 5	172	19– 3	57	11– 2	31	1– 4	3	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1913	109–14	301	3– 8	14	14– 0	48	29– 4	87	35– 0	90	22– 6	51	4– 0	8	1–12	3	0– 0	0	0– 0	0	0– 0	0	....	
1914	168–13	455	2–14	13	17– 2	58	47– 0	139	46– 7	120	44– 7	103	10– 6	21	0– 9	1	0– 0	0	0– 0	0	0– 0	0	....	
1915	228– 8	600	1–11	8	9– 9	36	44– 2	138	54– 2	150	60–14	150	33– 3	72	17– 2	33	5– 4	9	1–14	3	0–11	1	....	
Average	**167.3**	**490**	**22.0**	**94**	**22.8**	**79**	**34.9**	**105**	**33.7**	**98**	**32.2**	**77**	**11.9**	**25**	**4.9**	**9**	**1.3**	**2**	**0.5**	**0.8**	**0.2**	**0.3**	....	
Standard grade—																								
1912	20– 4	97	14–15	78	4–15	18	0– 0	0	0– 6	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1913	18– 7	63	4–14	23	5–10	19	3–10	10	2–14	8	0– 7	1	1– 0	2	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1914	36–13	113	5– 4	26	7–10	25	10–12	31	3– 6	9	5– 6	13	2–12	6	1–11	3	0– 0	0	0– 0	0	0– 0	0	....	
1915	25–10	77	2– 2	12	3– 0	11	6– 8	20	4– 6	12	6– 0	15	2– 0	4	1–10	3	0– 0	0	0– 0	0	0– 0	0	....	
Average	**25.3**	**88**	**6.8**	**35**	**5.3**	**18**	**5.2**	**15**	**2.8**	**8**	**3.0**	**7**	**1.4**	**3**	**0.8**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	....	
Cull fruits—																								
1912	5– 8	30																						
1913	9– 8	40																						
1914	6– 6	41																						
1915	7–13	23																						
Average	**7.3**	**34**																						
Total crop—																								
1912	187–12	730	95– 1	418	55– 4	190	19– 3	57	11– 8	32	1– 4	3	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	7	
1913	137–13	404	8– 6	37	19–10	67	32–14	97	37–14	98	22–13	52	5– 0	10	1–12	3	0– 0	0	0– 0	0	0– 0	0	0	
1914	212– 0	608	8– 2	39	24–12	83	57–12	170	49–13	129	49–13	116	13– 2	27	2– 4	4	0– 0	0	0– 0	0	0– 0	0	4	
1915	261–15	700	3–13	20	12– 9	47	50–10	158	58– 8	162	66–14	165	35– 3	76	18–12	36	5– 4	9	1–14	3	0–11	1	4	
Average	**199.9**	**611**	**28.8**	**129**	**28.0**	**97**	**40.1**	**121**	**39.4**	**105**	**35.2**	**84**	**13.3**	**28**	**5.7**	**11**	**1.3**	**2**	**0.5**	**0.8**	**0.2**	**0.3**	**4**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
248. Washington strain:																							
Orchard grade—																							
1912	208- 3	593	15- 5	57	32-10	104	30- 6	86	64- 0	163	40-15	93	17- 2	76	4- 2	8	3-11	6	0- 0	0	0- 0	0	....
1913	136-14	384	6- 3	26	17- 1	61	41- 5	125	27- 2	71	31- 3	73	9-10	20	4- 6	8	0- 0	0	0- 0	0	0- 0	0	....
1914	150-11	349	1- 0	4	5- 0	17	21- 1	59	36- 8	91	47- 8	104	29-14	58	7-13	13	1- 4	2	0-11	1	0- 0	0	....
1915	159- 8	359	0- 0	0	2- 4	8	12- 0	37	22-10	60	38-14	92	38-14	82	31-10	59	7- 3	12	6- 1	9	0- 0	0	....
Average	**163.8**	**421**	**5.6**	**22**	**14.2**	**48**	**26.2**	**77**	**37.6**	**96**	**39.6**	**91**	**23.9**	**59**	**12.0**	**22**	**3.0**	**5**	**1.7**	**3**	**0**	**0**	....
Standard grade—																							
1912	20- 2	69	7- 6	34	3- 2	10	2-12	8	4-11	12	1-11	4	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	20- 6	74	7- 6	34	5-12	20	5- 2	15	0-12	2	0-14	2	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	20- 1	65	3-11	19	4- 7	14	8- 3	23	1- 8	4	1- 4	3	1- 0	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	23- 4	64	2- 4	10	1-10	6	4-10	14	1- 8	4	6- 0	15	5-10	12	1- 1	2	0- 9	1	0- 0	0	0- 0	0	....
Average	**21.0**	**68**	**5.2**	**24**	**3.7**	**13**	**5.2**	**15**	**2.1**	**6**	**2.5**	**6**	**1.9**	**4**	**0.3**	**0.5**	**0.1**	**0.3**	**0**	**0**	**0**	**0**	....
Cull fruits—																							
1912	21- 7	76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	19- 1	76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	3-15	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	15-11	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**15.0**	**55**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	249-12	738	22-11	91	35-12	114	33- 2	94	68-11	175	42-10	97	17-10	77	4- 2	8	3-11	6	0- 0	0	0- 0	0	1
1913	176- 5	534	13- 9	60	22-13	81	46- 7	140	27-14	73	32- 1	75	10- 2	21	4- 6	8	0- 0	0	0- 0	0	0- 0	0	1
1914	174-11	437	4-11	23	9- 7	31	29- 4	82	38- 0	95	48-12	107	30-14	60	7-13	13	1- 4	2	0-11	1	0- 0	0	1
1915	198- 7	469	2- 4	10	3-14	14	16-10	51	24- 2	64	44-14	107	44- 8	94	32-11	61	7-12	13	6- 1	9	0- 0	0	2
Average	**199.8**	**545**	**10.8**	**46**	**18.0**	**60**	**31.4**	**92**	**39.7**	**102**	**42.1**	**97**	**25.8**	**63**	**12.3**	**23**	**3.2**	**5**	**1.7**	**3**	**0**	**0**	**1**

249. Golden Nugget strain:																								
Orchard grade—																								
1912																								
1913																								
1914	160- 6	412	6-14	27	24- 2	77	39-14	108	38- 3	94	39- 6	84	11- 6	21	0- 9	1	0- 0	0	0- 0	0	0- 0	0		
1915	112- 1	245	0- 0	0	2- 2	7	12- 2	34	13-11	35	29-14	67	31- 8	63	14-15	27	5-11	9	2- 2	3	0- 0	0		
Average	**136.2**	**329**	**3.4**	**14**	**13.1**	**42**	**26.0**	**71**	**25.9**	**65**	**34.6**	**76**	**21.4**	**42**	**7.8**	**14**	**2.8**	**5**	**1.1**	**2**	**0**	**0**		
Standard grade—																								
1912																								
1913																								
1914	17-12	54	3-12	17	3-10	12	4-14	13	2- 2	5	1-14	4	0-15	2	0- 9	1	0- 0	0	0- 0	0	0- 0	0		
1915	43- 5	100	1- 4	7	1- 4	4	4-12	13	4- 6	11	10- 4	24	13- 9	28	3-15	7	2- 8	4	1- 7	2	0- 0	0		
Average	**30.5**	**77**	**2.5**	**12**	**2.4**	**8**	**4.8**	**13**	**3.3**	**8**	**6.1**	**14**	**7.3**	**15**	**2.3**	**4**	**1.3**	**2**	**0.7**	**1**	**0**	**0**		
Cull fruits—																								
1912																								
1913																								
1914	10- 0	42																						
1915	55- 6	175																						
Average	**32.7**	**109**																						
Total crop—																								
1912																								
1913																								
1914	188- 2	508	10-10	44	27-12	89	44-12	121	40- 5	99	41- 4	88	12- 5	23	1- 2	2	0- 0	0	0- 0	0	0- 0	0	10	
1915	210-12	520	1- 4	7	3- 6	11	16-14	47	18- 1	46	40- 2	91	45- 1	91	18-14	34	8- 3	13	3- 9	5	0- 0	0	9	
Average	**199.4**	**514**	**5.9**	**26**	**15.6**	**50**	**30.8**	**84**	**29.2**	**73**	**40.7**	**90**	**28.7**	**57**	**10.0**	**18**	**4.1**	**7**	**1.8**	**3**	**0**	**0**	**10**	
269. Washington strain:																								
Orchard grade—																								
1912	232-15	569	8-13	35	16-11	52	23-14	69	50- 3	132	42- 6	99	56- 1	117	4-11	9	23-12	49	6- 8	7	0- 0	0		
1913	113-14	285	3- 8	15	9-12	33	22- 9	67	18- 2	46	25- 6	59	15- 9	32	14- 5	26	2-10	4	2- 1	3	0- 0	0		
1914	157- 3	412	3-12	15	16-12	56	40- 4	115	43-10	111	38- 2	86	13- 8	27	0- 9	1	0-10	1	0- 0	0	0- 0	0		
1915	113-14	226	0- 0	0	0-11	3	5- 2	15	7- 6	19	22- 2	50	28- 2	57	29- 4	51	9- 8	15	8- 6	12	3- 2	4		
Average	**154.5**	**373**	**4.0**	**16**	**11.0**	**36**	**23.0**	**67**	**29.8**	**77**	**32.0**	**74**	**28.3**	**58**	**12.2**	**22**	**9.1**	**17**	**4.2**	**6**	**0.8**	**1**		
Standard grade—																								
1912	36-12	114	9- 4	44	4- 1	14	4-14	14	6- 0	15	6-10	15	2- 4	5	2- 8	5	1- 3	2	0- 0	0	0- 0	0		
1913	38- 5	110	6- 5	26	8- 6	28	7-12	22	4- 6	11	5- 8	12	3- 1	6	1-10	3	0-10	1	0-11	1	0- 0	0		
1914	20-11	71	6-14	34	2- 6	8	6-10	18	2- 6	6	0-14	2	1- 0	2	0- 9	1	0- 0	0	0- 0	0	0- 0	0		
1915	14- 5	33	0- 6	2	0- 5	1	1- 4	4	1- 0	3	3- 0	7	5- 0	10	1-10	3	1-11	3	0- 0	0	0- 0	0		
Average	**27.5**	**82**	**5.7**	**27**	**3.8**	**13**	**5.1**	**15**	**3.4**	**9**	**4.0**	**9**	**2.8**	**6**	**1.6**	**3**	**0.9**	**2**	**0.2**	**0.3**	**0**	**0**		

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
269. Washington strain—Con.																							
Cull fruits—																							
1912	16–14	59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	11– 2	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	4– 4	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	2– 7	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**8.7**	**34**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	286– 9	742	18– 1	79	20–12	66	28–12	83	56– 3	147	49– 0	114	58– 5	122	7– 3	14	24–15	51	6– 8	7	0– 0	0	5
1913	163– 5	435	9–13	41	18– 2	61	30– 5	89	22– 8	57	30–14	71	18–10	38	15–15	29	3– 4	5	2–12	4	0– 0	0	0
1914	182– 2	513	10–10	49	19– 2	64	46–14	133	46– 0	117	39– 0	88	14– 8	29	1– 2	2	0–10	1	0– 0	0	0– 0	0	8
1915	130–10	267	0– 6	2	1– 3	4	6– 6	19	8– 7	22	25– 2	57	33– 3	67	30–14	54	11– 3	18	8– 6	12	3– 2	4	1
Average	**190.7**	**489**	**9.7**	**43**	**14.8**	**49**	**28.1**	**81**	**33.3**	**86**	**36.0**	**83**	**31.2**	**64**	**13.8**	**25**	**10.0**	**19**	**4.4**	**6**	**0.8**	**1**	**4**
270. Golden Nugget strain:																							
Orchard grade—																							
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	75 11	139	0– 3	1	1– 9	5	3–10	10	7–14	19	11– 8	24	16– 0	29	21– 2	33	8– 0	11	3– 3	4	2–10	3	.....
1915	144 10	275	0– 3	1	0–14	3	6– 1	18	10–12	28	21–12	49	23– 1	47	37– 5	65	18– 6	29	12– 8	18	13–12	17	.....
Average	**110.2**	**207**	**0.2**	**1**	**1.2**	**4**	**4.8**	**14**	**9.3**	**24**	**16.6**	**37**	**19.5**	**38**	**29.2**	**49**	**13.2**	**20**	**7.8**	**11**	**8.2**	**10**	.....
Standard grade—																							
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	18– 2	40	0–12	4	1– 2	3	2– 7	7	1– 4	3	3–13	8	4– 2	8	3–14	6	0– 0	0	0–12	1	0– 0	0	.....
1915	33– 0	64	0– 3	1	2– 0	7	2– 5	7	1–10	4	2–15	7	5– 0	10	5–11	10	2– 9	4	5– 9	8	5– 2	6	.....
Average	**25.6**	**52**	**0.5**	**3**	**1.6**	**5**	**2.4**	**7**	**1.4**	**4**	**3.4**	**8**	**4.6**	**9**	**4.8**	**8**	**1.3**	**2**	**3.2**	**5**	**2.6**	**3**	.....

Cull fruits—																								
1912																								
1913																								
1914	6–6	18																						
1915	100–8	265																						
Average	**53.4**	**142**																						
Total crop—																								
1912																								
1913																								
1914	100–3	197	0–15	5	2–11	8	6–1	17	9–2	22	15–5	32	20–2	37	25–0	39	8–0	11	3–15	5	2–10	3	7	
1915	278–2	604	0–6	2	2–14	10	8–6	25	12–6	32	24–11	56	28–1	57	43–0	75	20–15	33	18–1	26	18–14	23	39	
Average	**189.2**	**401**	**0.7**	**4**	**2.8**	**9**	**7.2**	**21**	**10.8**	**27**	**20.0**	**44**	**24.1**	**47**	**34.0**	**57**	**14.5**	**22**	**11.0**	**16**	**10.8**	**13**	**23**	
293. Washington strain:																								
Orchard grade—																								
1912	224–15	508	3–3	12	13–13	43	20–13	58	48–13	121	47–5	104	58–10	115	4–15	9	24–11	42	2–12	4	0–0	0	....	
1913	102–1	219	0–4	1	3–2	10	12–14	35	14–1	35	25–5	56	17–1	34	18–6	32	5–14	9	3–8	5	1–10	2	....	
1914	121–14	266	0–4	1	6–2	20	12–7	35	26–5	64	35–14	76	22–10	42	11–12	19	4–4	6	1–8	2	0–12	1	....	
1915	152–8	355	0–0	0	4–6	15	15–3	45	35–0	91	45–8	105	23–12	49	20–3	37	4–4	7	2–12	4	1–8	2	....	
Average	**150.3**	**337**	**0.9**	**4**	**6.9**	**22**	**15.3**	**43**	**31.0**	**78**	**38.5**	**85**	**30.5**	**60**	**13.8**	**24**	**9.8**	**16**	**2.6**	**4**	**1.0**	**1**	....	
Standard grade—																								
1912	27–15	74	5–10	21	2–8	8	2–12	8	5–14	14	5–9	12	5–0	10	0–0	0	0–10	1	0–0	0	0–0	0	....	
1913	18–11	44	0–14	3	1–14	6	2–8	7	2–0	5	6–12	15	2–3	4	1–3	2	0–10	1	0–11	1	0–0	0	....	
1914	18–4	48	3–4	15	1–3	4	4–3	11	1–5	3	1–14	4	3–14	7	1–1	2	0–0	0	1–8	2	0–0	0	....	
1915	18–13	52	1–15	10	0–14	3	4–6	13	3–0	8	2–2	5	4–4	9	2–4	4	0–0	0	0–0	0	0–0	0	....	
Average	**20.9**	**55**	**2.9**	**12**	**1.6**	**5**	**3.5**	**10**	**3.0**	**8**	**4.1**	**9**	**3.8**	**8**	**1.1**	**2**	**0.3**	**0.5**	**0.5**	**0.8**	**0**	**0**	....	
Cull fruits—																								
1912	17–9	65																						
1913	9–11	32																						
1914	4–3	17																						
1915	4–10	18																						
Average	**9.0**	**33**																						
Total crop—																								
1912	270–7	647	8–13	33	16–5	51	23–9	66	54–11	135	52–14	116	63–10	125	4–15	9	25–5	43	2–12	4	0–0	0	3	
1913	130–7	295	1–2	4	5–0	16	15–6	42	16–1	40	32–1	71	19–4	38	19–9	34	6–8	10	4–3	6	1–10	2	0	
1914	144–5	331	3–8	16	7–5	24	16–10	46	27–10	67	37–12	80	26–8	49	12–13	21	4–4	6	3–0	4	0–12	1	...2	
1915	175–15	425	1–15	10	5–4	18	19–9	58	38–0	99	47–10	110	28–0	58	22–7	41	4–4	7	2–12	4	1–8	2	...1	
Average	**180.3**	**425**	**3.8**	**16**	**8.5**	**27**	**18.8**	**53**	**34.1**	**85**	**42.6**	**94**	**34.3**	**68**	**14.9**	**26**	**10.1**	**17**	**3.2**	**5**	**1.0**	**1**	**2**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
318. Washington strain:																							
Orchard grade—																							
1912	125- 3	286	0- 3	1	0-11	3	6-14	20	17- 9	49	27- 6	67	36-14	80	23-10	46	8- 2	14	3- 1	5	0-13	1	....
1913	53- 7	122	0- 0	0	0- 8	2	2-12	9	8- 3	23	9-12	24	10- 0	22	7-13	16	7-15	15	5-14	10	0-10	1	....
1914	191-15	524	8-10	39	31- 5	107	45- 3	132	33- 8	87	36-10	85	24-10	51	9 11	18	2- 6	4	0- 0	0	0- 0	0	....
1915	126- 0	256	0- 0	0	0- 8	2	8- 9	24	12-12	32	25-10	57	35- 4	70	17-11	32	14-15	24	8- 3	12	2- 8	3	....
Average	**124.1**	**297**	**2.2**	**10**	**8.3**	**29**	**15.8**	**46**	**18.0**	**48**	**24.8**	**58**	**26.7**	**56**	**14.7**	**28**	**8.3**	**14**	**4.3**	**7**	**1.0**	**2**	....
Standard grade—																							
1912	9-12	25	0- 6	2	0- 0	0	0-14	3	2- 3	6	3- 3	8	0- 0	0	0-14	2	1-10	3	0-10	1	0- 0	0	....
1913	11-12	30	0- 0	0	0- 0	0	1- 3	4	3- 6	10	3- 9	9	1- 6	3	0- 9	1	1-11	3	0- 0	0	0- 0	0	....
1914	31- 1	105	7- 6	36	6- 8	24	7- 4	22	4-10	12	1-12	4	3- 9	7	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	27- 9	62	1- 1	4	1- 0	3	3- 0	8	5-12	14	7-14	17	7- 0	13	0- 9	1	0-10	1	0-11	1	0- 0	0	....
Average	**20.0**	**55**	**2.2**	**11**	**1.9**	**7**	**3.1**	**9**	**4.0**	**11**	**4.1**	**10**	**3.0**	**6**	**0.5**	**1**	**1.0**	**2**	**0.3**	**0.5**	**0**	**0**	....
Cull fruits—																							
1912	23-12	66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	62- 7	196	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	8- 1	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	10- 6	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**26.2**	**84**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	158-11	377	0- 9	3	0-11	3	7-12	23	19-12	55	30- 9	75	36-14	80	24- 8	48	9-12	17	3-11	6	0-13	1	0
1913	127-10	348	0- 0	0	0- 8	2	3-15	13	11- 9	33	13- 5	33	11- 6	25	8- 6	17	9-10	18	5-14	10	0-10	1	0
1914	231- 1	673	16- 0	75	37-13	131	52- 7	154	38 -2	99	38- 6	89	28- 3	58	9-11	18	2- 6	4	0- 0	0	0- 0	0	4
1915	163-15	347	1- 1	4	1- 8	5	11- 9	32	18- 8	46	33- 8	74	42- 4	83	18- 4	33	15- 9	25	8-14	13	2- 8	3	7
Average	**170.3**	**436**	**4.4**	**21**	**10.1**	**35**	**18.9**	**56**	**22.0**	**58**	**28.9**	**68**	**29.7**	**62**	**15.2**	**29**	**9.3**	**16**	**4.6**	**7**	**1.0**	**2**	**3**

339. Wrinkled Australian strain:																								
Orchard grade—																								
1912	73- 7	206	13- 5	50	17- 8	53	11- 6	31	17- 6	43	9- 8	21	3- 2	6	0-10	1	0-10	1	0- 0	0	0- 0	0	....	
1913	40-11	132	5-14	28	7-13	28	14-10	45	6- 0	16	5-14	14	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	27- 8	64	0- 0	0	1- 2	4	3- 1	9	7- 6	19	7-11	17	5- 4	10	2- 6	4	0- 0	0	0-10	1	0- 0	0	....	
1915	48-12	97	0- 0	0	0- 0	0	2- 7	7	4- 6	11	10- 3	23	10-14	22	9-11	17	7- 1	11	1-14	3	2- 4	3	....	
Average	**47.6**	**125**	**4.8**	**20**	**6.6**	**21**	**7.9**	**24**	**8.8**	**22**	**8.3**	**19**	**4.9**	**10**	**3.2**	**6**	**1.9**	**3**	**0.6**	**1**	**0.6**	**0.8**	....	
Standard grade—																								
1912	116-11	312	24-12	102	14-10	44	19-14	57	26-11	68	9- 8	21	18-14	16	0- 0	0	2- 6	4	0- 0	0	0- 0	0	....	
1913	110-11	375	28-11	137	28- 5	96	23- 8	68	14-11	38	11-12	28	3-12	8	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	125- 6	315	6- 4	34	7-15	25	23-12	66	21- 2	53	31- 3	70	19-12	40	12-12	23	1-14	3	0- 0	0	0-12	1	....	
1915	19- 1	41	0-11	4	0- 9	2	0-11	2	0- 6	1	1- 2	3	4-10	10	5-14	11	3- 2	5	1- 4	2	0-12	1	....	
Average	**93.0**	**261**	**15.1**	**69**	**12.9**	**42**	**17.0**	**48**	**15.7**	**40**	**13.4**	**31**	**11.8**	**19**	**4.7**	**9**	**1.8**	**3**	**0.3**	**0.5**	**0.4**	**0.5**	....	
Cull fruits—																								
1912	20-12	84																					....	
1913	45- 4	196																					....	
1914	16- 6	46																					....	
1915	3-11	16																					....	
Average	**21.5**	**86**																					....	
Total crop—																								
1912	210-14	602	38- 1	152	32- 2	97	31- 4	88	44- 1	111	19- 0	42	22- 0	22	0-10	1	3- 0	5	0- 0	0	0- 0	0	304	
1913	196-10	703	34- 9	165	36- 2	124	38- 2	113	20-11	54	17-10	42	4- 4	9	0- 0	0	0- 0	0	0- 0	0	0- 0	0	385	
1914	169- 4	425	6- 4	34	9- 1	29	26-13	75	28- 8	72	38-14	87	25- 0	50	15- 2	27	1-14	3	0-10	1	0-12	1	307	
1915	71- 8	154	0-11	4	0- 9	2	3- 2	9	4-12	12	11- 5	26	13- 8	32	15- 9	28	10- 3	16	3- 2	5	3- 0	4	37	
Average	**162.1**	**471**	**19.9**	**89**	**19.5**	**63**	**24.8**	**71**	**24.5**	**62**	**21.7**	**49**	**16.7**	**28**	**7.8**	**14**	**3.8**	**6**	**0.9**	**2**	**0.9**	**1**	**258**	
342. Thomson strain:																								
Orchard grade—																								
1912	94- 3	387	56-11	253	25- 4	97	8- 5	26	2-12	8	1- 3	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1913	85- 2	244	6- 2	26	10- 4	36	26- 3	78	21- 9	57	16- 2	37	4- 5	9	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1914	156-15	472	14- 9	62	31-10	112	50- 6	150	32-10	86	20-13	48	6- 6	13	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....	
1915	165-14	644	44-10	212	57- 5	225	49- 1	164	11- 0	33	3-14	10	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
Average	**125.5**	**437**	**30.5**	**138**	**31.1**	**118**	**33.5**	**105**	**17.0**	**46**	**10.5**	**25**	**2.7**	**6**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	....	
Standard grade—																								
1912	28-13	156	26- 7	148	1- 2	4	1- 4	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1913	23-13	81	5-15	29	5- 6	19	4-10	13	3- 4	9	4- 2	10	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	11- 6	47	5-12	31	1- 6	5	1- 6	4	0- 6	1	2- 0	5	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1915	62- 1	310	42- 8	238	11- 4	44	6-15	24	1- 0	3	0- 6	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
Average	**31.5**	**148**	**20.2**	**112**	**4.8**	**18**	**3.5**	**11**	**1.2**	**3**	**1.6**	**4**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
342. Thomson strain—Con.																							
Cull fruits—																							
1912	3-12	22																					
1913	7- 6	25																					
1914	3- 9	16																					
1915	2 11	13																					
Average	**4.3**	**19**																					
Total crop—																							
1912	126-12	565	83- 2	401	26- 6	101	9- 9	30	2-12	8	1- 3	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	11
1913	116- 5	350	12- 1	55	15-10	55	30-13	91	24 13	66	20- 4	47	4 13	10	0- 9	1	0- 0	0	0- 0	0	0- 0	0	0
1914	171-14	535	20- 5	93	33- 0	117	51-12	154	33- 0	87	22-13	53	6 14	14	0- 9	1	0- 0	0	0- 0	0	0- 0	0	3
1915	230-10	967	87- 2	450	68- 9	269	56- 0	188	12- 0	36	4- 4	11	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	15
Average	**161.4**	**604**	**50.7**	**250**	**35.9**	**136**	**37.0**	**116**	**18.1**	**49**	**12.1**	**29**	**2.9**	**6**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**7**
344. Washington strain:																							
Orchard grade—																							
1912	137-14	318	4- 5	16	12-10	38	16- 4	44	41- 4	98	23- 9	50	26- 1	49	4- 8	8	8- 0	13	1- 5	2	0- 0	0	....
1913	25- 5	49	0- 0	0	0- 0	0	2- 8	7	1-12	5	2- 9	6	3-10	7	11- 6	19	1- 5	2	1- 7	2	0-12	1	....
1914	81- 6	148	0- 0	0	0- 0	0	2- 1	6	6- 6	15	17- 2	35	30 14	55	19- 9	30	3-12	5	0 12	1	0-14	1	....
1915	197 14	329	0- 0	0	0- 0	0	0- 5	1	3- 8	9	11- 2	24	35- 9	69	68- 8	117	33- 2	50	22-11	32	23- 1	27	....
Average	**110.6**	**211**	**1.1**	**4**	**3.2**	**10**	**5.3**	**15**	**13.2**	**32**	**13.6**	**29**	**24.0**	**45**	**26.0**	**44**	**11.5**	**18**	**6.5**	**9**	**6.2**	**7**	....
Standard grade—																							
1912	26-14	69	3- 6	15	2-19	8	3- 6	9	7- 6	17	6-11	14	2- 2	4	0- 0	0	1- 5	2	0- 0	0	0- 0	0	....
1913	14-14	33	0- 4	1	1- 3	4	2- 0	6	0-14	2	3-11	8	3-10	7	1- 2	2	0-10	1	0-12	1	0-12	1	....
1914	24-11	52	1- 6	6	0-15	3	2- 5	6	3- 0	7	3-12	8	6-12	12	4- 4	7	0-11	1	0-12	1	0-14	1	....
1915	59- 3	121	0- 0	0	1- 3	4	5- 7	15	2- 5	6	10- 2	23	21- 9	43	9-12	17	5- 2	8	1- 7	2	2- 4	3	....
Average	**31.4**	**69**	**1.3**	**6**	**1.5**	**5**	**3.3**	**9**	**3.4**	**8**	**6.1**	**13**	**8.5**	**17**	**3.8**	**7**	**1.9**	**3**	**0.7**	**1**	**1.0**	**1**	....

Cull fruits—																								
1912	11–9	40																						
1913	34–1	119																						
1914	3–8	7																						
1915	23–3	60																						
Average	**18.1**	**57**																						
Total crop—																								
1912	176–5	427	7–11	31	15–4	46	19–10	53	48–10	115	30–4	64	28–3	53	4–8	8	9–5	15	1–5	2	0–0	0	0	
1913	74–4	201	0–4	1	1–3	4	4–8	13	2–10	7	6–4	14	7–4	14	12–8	21	1–15	3	2–3	3	1–8	2	0	
1914	109–9	207	1–6	6	0–15	3	4–6	12	9–6	22	20–14	43	37–10	67	23–13	37	4–7	6	1–8	2	1–12	2	10	
1915	280–4	510	0–0	0	1–3	4	5–12	16	5–13	15	21–4	47	57–2	112	78–4	134	38–4	58	24–2	34	25–5	30	0	
Average	**160.1**	**336**	**2.3**	**9**	**4.6**	**14**	**8.6**	**23**	**16.6**	**40**	**19.7**	**42**	**32.5**	**62**	**29.8**	**50**	**13.5**	**21**	**7.3**	**10**	**7.1**	**9**	**3**	
347. Yellow Washington strain:																								
Orchard grade—																								
1912	121–6	314	0–7	7	5–4	20	23–7	73	24–0	65	32–8	79	19–1	40	10–9	20	4–12	8	1–6	2	0–0	0		
1913	80–3	162	0–0	0	0–10	2	2–4	7	5–1	14	11–9	28	12–13	28	10–14	22	16–8	30	13–14	22	6–10	9		
1914	209–5	490	3–2	14	6–14	24	29–12	88	34–1	89	49–9	113	47–1	96	20–4	37	10–5	17	7–9	11	0–12	1		
1915	83–9	158	0–0	0	0–4	1	3–4	9	8–0	20	11–15	26	16–5	32	17–6	31	13–15	22	7–1	10	5–7	7		
Average	**123.6**	**281**	**0.9**	**5**	**3.3**	**12**	**14.7**	**44**	**17.8**	**47**	**26.4**	**62**	**23.8**	**49**	**14.8**	**28**	**11.4**	**19**	**7.5**	**11**	**3.2**	**4**		
Standard grade—																								
1912	19–9	59	1–4	8	1–3	4	4–4	14	4–8	13	6–6	16	2–0	4	0–0	0	0–0	0	0–0	0	0–0	0		
1913	11–6	27	0–4	2	0–4	1	1–1	3	1–2	3	2–9	6	4–14	10	0–10	1	0–10	1	0–0	0	0–0	0		
1914	17–14	47	1–11	9	1–0	3	3–13	11	2–12	7	3–10	8	3–11	7	0–10	1	0–11	1	0–0	0	0–0	0		
1915	25–3	50	0–3	1	0–0	0	1–6	4	4–1	10	4–12	10	9–15	18	1–15	3	0–10	1	2—5	3	0–0	0		
Average	**18.5**	**46**	**0.8**	**5**	**0.6**	**2**	**2.6**	**8**	**3.1**	**8**	**4.3**	**10**	**5.1**	**10**	**0.8**	**1**	**0.5**	**0.8**	**0.6**	**0.8**	**0**	**0**		
Cull fruits—																								
1912	10–2	92																						
1913	50–8	145																						
1914	6–1	22																						
1915	3–6	9																						
Average	**17.5**	**67**																						
Total crop—																								
1912	151–1	465	1–11	15	6–7	24	27–11	87	28–8	78	38–14	95	21–1	44	10–9	20	4–12	8	1–6	2	0–0	0	0	
1913	142–1	334	0–4	2	0–14	3	3–5	10	6–3	17	14–2	34	17–11	38	11–8	23	17–2	31	13–14	22	6–10	9	0	
1914	233–4	559	4–13	23	7–14	27	33–9	99	36–13	96	53–3	121	50–12	103	20–14	38	11–0	18	7–9	11	0–12	1	4	
1915	112–2	217	0–3	1	0–4	1	4–10	13	12–1	30	16–11	36	23–4	50	19–5	34	14–9	23	9–6	13	5–7	7	3	
Average	**159.6**	**394**	**1.7**	**10**	**3.9**	**14**	**17.3**	**52**	**20.9**	**55**	**30.7**	**72**	**28.9**	**59**	**15.6**	**29**	**11.9**	**20**	**8.0**	**12**	**3.2**	**4**	**1.8**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
371. Thomson strain:																							
Orchard grade—																							
1912	117- 5	352	16- 4	71	20-10	69	21- 1	64	28- 0	76	18- 3	44	11- 9	25	1-10	3	0- 0	0	0- 0	0	0- 0	0	....
1913	85- 5	214	0- 8	2	5-14	20	17- 3	51	21-12	56	23- 7	53	11- 6	23	3 14	7	0-10	1	0-11	1	0- 0	0	....
1914	132-15	331	2- 2	9	6- 3	26	23-12	68	37-13	95	43-11	96	14-13	29	3-14	7	0- 0	0	0-11	1	0- 0	0	....
1915	179-11	509	4- 8	20	19- 2	71	50- 4	157	44- 4	122	34-12	84	17- 5	37	7-12	15	1-12	3	0- 0	0	0- 0	0	....
Average	**128.8**	**352**	**5.8**	**26**	**13.0**	**47**	**28.1**	**85**	**33.0**	**87**	**30.0**	**69**	**13.8**	**29**	**4.3**	**8**	**0.6**	**1**	**0.3**	**0.5**	**0**	**0**	....
Standard grade—																							
1912	7-12	24	0-15	4	3- 0	10	2- 1	6	0-13	2	0- 7	1	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	17- 3	48	0-15	4	4- 4	14	4- 3	12	2-10	7	2- 3	5	3- 0	6	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	14- 1	50	4-14	24	3- 2	10	3- 2	9	1-10	4	1- 5	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	21- 4	75	4-10	25	4-12	17	4- 1	13	3- 4	9	3-11	9	0 14	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
Average	**15.1**	**49**	**2.8**	**14**	**3.8**	**13**	**3.4**	**10**	**2.1**	**6**	**1.9**	**5**	**1.1**	**2**	**0**	**0**	**0**	**0**	**0**	**0.**	**0**	**0**	....
Cull fruits—																							
1912	4- 6	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	8- 6	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	7- 3	26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	6- 2	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**6.5**	**24**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	129- 7	391	17- 3	75	23-10	79	23- 2	70	28-13	78	18-10	45	12- 1	26	1-10	3	0- 0	0	0- 0	0	0- 0	0	0
1913	110-14	290	1- 7	6	10- 2	34	21- 6	63	24- 6	63	25 10	58	14- 6	29	3-14	7	0-10	1	0-11	1	0- 0	0	0
1914	154- 3	407	7- 0	33	9- 5	36	26-14	77	39- 7	99	45- 0	99	14-13	29	3-14	7	0- 0	0	0-11	1	0- 0	0	0
1915	207- 1	609	9- 2	45	23-14	88	54- 5	170	47- 8	131	38- 7	93	18- 3	39	7-12	15	1-12	3	0- 0	0	0- 0	0	15
Average	**150.4**	**424**	**8.7**	**40**	**16.7**	**59**	**31.4**	**95**	**35.0**	**93**	**31.9**	**74**	**14.9**	**31**	**4.3**	**8**	**0.6**	**1**	**0.3**	**0.5**	**0**	**0**	**4**

372. Washington strain:																							
Orchard grade—																							
1912	122- 4	286	5- 9	21	9- 6	29	14- 5	40	29- 2	72	18- 4	40	26- 0	51	3-12	7	13-14	23	2- 0	3	0- 0	0	....
1913	92- 2	259	7-12	36	14- 0	50	21-14	64	14-14	38	22-11	51	5- 2	10	5- 1	9	0- 0	0	0- 0	0	0-12	1	....
1914	136-11	309	1-14	7	6- 4	20	22-12	62	28-10	69	42- 1	89	23- 6	44	8- 3	13	2- 0	3	0-12	1	0-13	1	....
1915	109- 4	203	0- 3	1	0- 4	1	3- 2	9	7-13	20	17- 0	38	21-11	42	29- 5	51	11- 4	17	8-10	12	10- 0	12	....
Average	**115.1**	**264**	**3.9**	**16**	**7.5**	**25**	**15.5**	**44**	**20.1**	**50**	**25.0**	**54**	**19.0**	**37**	**11.6**	**20**	**6.8**	**11**	**2.9**	**4**	**2.9**	**3**	....
Standard grade—																							
1912	8- 9	25	1- 9	8	0-14	3	1- 0	3	2- 1	5	0-15	2	1- 8	3	0- 0	0	0-10	1	0- 0	0	0- 0	0	....
1913	10- 3	34	2-14	13	3- 5	11	2- 2	6	0-12	2	0- 0	0	0- 8	1	0-10	1	0- 0	0	0- 0	0	0- 0	0	....
1914	20- 7	52	1- 6	6	3- 5	10	6- 7	17	2-10	6	2- 4	5	3- 4	6	1- 3	2	0- 0	0	0- 0	0	0- 0	0	....
1915	15-15	35	0- 6	2	0-10	2	1- 1	3	1-10	4	2- 0	5	4- 4	9	2-13	5	1- 2	2	1- 5	2	0-12	1	....
Average	**13.8**	**37**	**1.5**	**7**	**2.0**	**6**	**2.7**	**7**	**1.8**	**4**	**1.3**	**3**	**2.4**	**5**	**1.2**	**2**	**0.4**	**0.8**	**0.3**	**0.5**	**0.2**	**0.3**	....
Cull fruits—																							
1912	34- 2	91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	23- 5	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	11- 6	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	15-13	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**21.2**	**62**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	164-15	402	7- 2	20	10- 4	32	15- 5	43	31- 3	77	19- 3	42	27- 8	54	3-12	7	14- 8	24	2- 0	3	0- 0	0	0
1913	125-10	373	10-10	49	17- 5	61	24- 0	70	15-10	40	22-11	51	5-10	11	5-11	10	0- 0	0	0- 0	0	0-12	1	0
1914	168- 8	398	3- 4	13	9- 9	30	29- 3	79	31- 4	75	44- 5	94	26-10	50	9- 6	15	2- 0	3	0-12	1	0-13	1	5
1915	141- 0	278	0- 9	3	0-14	3	4- 3	12	9- 7	24	19- 0	43	25-15	51	32- 2	56	12- 6	19	9-15	14	10-12	13	3
Average	**150.0**	**362**	**5.4**	**24**	**9.5**	**32**	**18.2**	**51**	**21.9**	**54**	**26.3**	**58**	**21.4**	**42**	**12.7**	**22**	**7.2**	**12**	**3.2**	**5**	**3.1**	**4**	**2**
391. Golden Nugget strain:																							
Orchard grade—																							
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	116- 6	319	4-12	21	21- 8	72	33- 4	94	28- 6	71	21- 3	47	6- 3	12	1- 2	2	0- 0	0	0- 0	0	0- 0	0	....
1915	54- 1	128	0- 7	2	3- 3	11	7-12	23	7- 5	19	12-12	30	10- 0	21	8-13	16	1-12	3	2- 1	3	0- 0	0	....
Average	**85.2**	**224**	**2.6**	**12**	**12.3**	**42**	**20.5**	**59**	**17.8**	**45**	**17.0**	**39**	**8.1**	**17**	**5.0**	**9**	**0.9**	**2**	**1.0**	**2**	**0**	**0**	....
Standard grade—																							
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	16-12	52	3- 4	16	1-12	6	6-14	19	1-10	4	1-12	4	1- 8	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	37-14	112	3- 8	16	9-13	34	8-11	26	3- 0	8	5- 7	13	5-12	12	1-11	3	0- 0	0	0- 0	0	0- 0	0	....
Average	**27.3**	**82**	**3.4**	**16**	**5.8**	**20**	**7.8**	**23**	**2.3**	**6**	**3.6**	**9**	**3.6**	**8**	**0.8**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	....

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																					
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
391. Golden Nugget strain—Continued.																							
Cull fruits—																							
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	8–5	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	47–15	197	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	28.1	122	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	141–7	417	8–0	37	23–4	78	40–2	113	30–0	75	22–15	51	7–11	15	1–2	2	0–0	0	0–0	0	0–0	0	2
1915	139–14	437	3–15	18	13–0	45	16–7	49	10–5	27	18–3	43	15–12	33	10–8	19	1–12	3	2–1	3	0–0	0	7
Average	**140.7**	**427**	**6.0**	**28**	**18.1**	**62**	**28.3**	**81**	**20.2**	**51**	**20.6**	**47**	**11.7**	**24**	**5.8**	**11**	**0.9**	**2**	**1.0**	**2**	**0**	**0**	**5**
392. Sporting Washington strain:																							
Orchard grade—																							
1912	47–0	111	0–13	3	3–4	11	3–9	10	11–4	30	7–14	18	12–0	25	2–2	4	4–2	7	2–0	3	0–0	0	....
1913	37–6	90	0–11	3	2–11	9	6–15	20	6–3	16	6–10	15	8–13	18	3–7	6	1–5	2	0–11	1	0–0	0	....
1914	67–2	131	0–0	0	0–4	1	1–1	3	5–8	14	17–15	39	22–11	43	12–9	21	1–14	3	4–8	6	0–12	1	....
1915	54–5	95	0–0	0	0–5	1	0–6	1	0–13	2	4–5	10	7–6	15	13–12	25	10–4	17	11–12	17	5–6	7	....
Average	**51.5**	**107**	**0.4**	**2**	**1.6**	**6**	**3.0**	**9**	**5.9**	**16**	**9.2**	**21**	**12.7**	**25**	**8.0**	**14**	**4.4**	**7**	**4.7**	**7**	**1.5**	**2**	....
Standard grade—																							
1912	82–5	236	10–12	47	11–10	38	18–10	54	20–4	51	13–8	31	5–14	12	0–0	0	1–11	3	0–0	0	0–0	0	....
1913	74–7	220	10–13	48	11–6	40	12–10	38	13–8	36	16–1	38	6–10	14	2–13	5	0–10	1	0–0	0	0–0	0	....
1914	87–5	209	3–2	13	4–6	15	18–9	52	10–7	26	19–4	43	20–4	41	9–4	16	0–10	1	0–11	1	0–12	1	....
1915	45–5	94	0–6	2	0–5	1	0–11	2	3–5	9	7–6	18	13–8	29	8–4	15	5–6	9	4–8	7	1–10	2	....
Average	**72.3**	**190**	**6.3**	**28**	**6.9**	**24**	**12.6**	**37**	**11.9**	**31**	**14.0**	**33**	**11.6**	**24**	**5.1**	**9**	**2.1**	**4**	**1.3**	**2**	**0.6**	**0.8**	....

Cull fruits—																								
1912	11- 4	51																						
1913	34- 0	115																						
1914	2-14	8																						
1915	16-12	43																						
Average	**16.2**	**54**																						
Total crop—																								
1912	140- 9	398	11- 9	50	14-14	49	22- 3	64	31- 8	81	21- 6	49	17-14	37	2- 2	4	5-13	10	2- 0	3	0- 0	0	192	
1913	145-13	425	11- 8	51	14- 1	49	19- 9	58	19-11	52	22-11	53	15- 7	32	6- 4	11	1-15	3	0-11	1	0- 0	0	229	
1914	157- 5	348	3- 2	13	4-10	16	19-10	55	15-15	40	37- 3	82	42-15	84	21-13	37	2- 8	4	5- 3	7	1- 8	2	142	
1915	116- 6	232	0- 6	2	0-10	2	1- 1	3	4- 2	11	11-11	28	20-14	44	22- 0	40	15-10	26	16- 4	24	7- 0	9	131	
Average	**140.0**	**351**	**6.6**	**29**	**8.5**	**29**	**15.6**	**45**	**17.8**	**46**	**23.2**	**53**	**24.3**	**49**	**13.0**	**23**	**6.5**	**11**	**6.0**	**9**	**2.1**	**3**	**174**	
393. Washington strain:																								
Orchard grade—																								
1912	111- 5	238	1- 2	4	4- 3	13	5- 4	15	18- 7	47	20- 7	46	28-10	57	5-14	11	19- 0	33	3-14	6	4- 8	6	....	
1913	87-14	228	4-10	20	6-10	24	18- 8	55	16-15	44	22- 4	50	10- 4	20	6-11	12	1- 4	2	0- 0	0	0-12	1	....	
1914	122-15	241	0- 0	0	0- 5	1	5-14	16	12- 2	29	42-10	89	35-13	65	21- 5	34	4-14	7	0- 0	0	0- 0	0	....	
1915	135-13	284	0- 3	1	0-14	3	5-10	17	11- 7	30	30- 0	70	38- 9	79	29-12	54	10- 6	17	8- 4	12	0-12	1	....	
Average	**114.5**	**248**	**1.5**	**6**	**3.0**	**10**	**8.8**	**26**	**14.7**	**38**	**28.8**	**64**	**28.3**	**55**	**15.9**	**28**	**8.9**	**15**	**3.0**	**5**	**1.5**	**2**	....	
Standard grade—																								
1912	13- 0	32	2- 2	9	1- 0	3	0- 0	0	1-10	4	1-12	4	2-15	6	1-10	3	1- 4	2	0-11	1	0- 0	0	....	
1913	8 10	28	2-12	12	1-14	6	1- 1	3	0-13	2	1-10	4	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	33-14	71	0-15	4	2- 0	6	3- 3	8	5-10	13	6-10	14	6- 0	11	7- 6	12	0-10	1	1- 8	2	0- 0	0	....	
1915	16-13	39	0- 4	2	0-10	2	1- 6	4	1- 2	3	3-12	9	6-10	14	0- 8	1	1- 4	2	1- 5	2	0- 0	0	....	
Average	**18.1**	**42**	**1.5**	**7**	**1.4**	**4**	**1.4**	**4**	**2.3**	**6**	**3.4**	**8**	**4.0**	**8**	**2.4**	**4**	**0.8**	**1**	**0.9**	**1**	**0**	**0**	....	
Cull fruits—																								
1912	2-10	8																						
1913	18- 0	55																						
1914	1- 8	8																						
1915	6-11	16																						
Average	**7.2**	**22**																						
Total crop—																								
1912	126-15	278	3- 4	13	5- 3	16	5- 4	15	20- 1	51	22- 3	50	31- 9	63	7- 8	14	20- 4	35	4- 9	7	4- 8	6	16	
1913	114- 8	311	7- 6	32	8- 8	30	19- 9	58	17-12	46	23-14	54	10-12	21	6-11	12	1- 4	2	0- 0	0	0-12	1	0	
1914	158- 5	320	0-15	4	2- 5	7	9- 1	24	17-12	42	49- 4	103	41-13	76	28-11	46	5- 8	8	1- 8	2	0- 0	0	4	
1915	159- 5	339	0- 7	3	1- 8	5	7- 0	21	12- 9	33	33-12	79	45- 3	93	30- 4	55	11-10	19	9- 9	14	0-12	1	4	
Average	**139.8**	**312**	**3.0**	**13**	**4.4**	**15**	**10.2**	**30**	**17.0**	**43**	**32.3**	**72**	**32.3**	**63**	**18.3**	**32**	**9.7**	**16**	**3.9**	**6**	**1.5**	**2**	**6**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
400. Yellow Washington strain:																							
Orchard grade—																							
1912	128- 9	314	0- 3	1	5-12	21	15- 9	49	24-12	67	30- 9	73	28- 9	61	15- 0	29	3- 7	6	4- 1	6	0-11	1	....
1913	34-11	58	0- 0	0	0- 0	0	0-10	2	1- 2	3	1-10	4	2- 3	5	2- 2	4	5- 4	9	10- 5	16	11- 7	15	....
1914	113-13	253	1- 6	6	6- 2	21	10-12	32	14-10	38	24-11	56	25- 5	51	12- 6	22	8-12	14	5-10	8	4- 3	5	....
1915	139- 3	283	0-11	3	3-11	12	13- 2	37	12- 0	30	22-12	51	30- 9	61	20- 2	36	19- 2	30	9- 0	13	8- 2	10	....
Average	**104.1**	**227**	**0.6**	**3**	**3.9**	**14**	**10.0**	**30**	**13.1**	**35**	**19.9**	**46**	**21.7**	**45**	**12.4**	**23**	**9.1**	**15**	**7.3**	**11**	**6.1**	**8**	....
Standard grade—																							
1912	11- 4	37	1- 6	7	1- 4	5	3- 0	10	3- 0	9	1- 9	4	0- 8	1	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1913	9-10	21	0- 0	0	0- 0	0	0- 4	1	2- 0	6	2- 1	5	1- 7	3	1- 0	2	1- 4	2	0- 0	0	1-10	2	....
1914	16- 0	41	1- 7	8	0-15	3	1-12	5	3- 3	8	3- 4	7	3-10	7	1- 3	2	0-10	1	0- 0	0	0- 0	0	....
1915	20- 6	44	0- 9	3	0- 4	1	1- 7	4	4- 7	11	4- 1	9	4- 4	8	2- 6	4	0-10	1	0-11	1	1-11	2	....
Average	**14.3**	**36**	**0.8**	**5**	**0.6**	**2**	**1.6**	**5**	**3.2**	**9**	**2.7**	**6**	**2.5**	**5**	**1.3**	**2**	**6**	**1**	**2**	**3**	**8**	**1**	....
Cull fruits—																							
1912	12- 2	49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	39-10	104	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	3-13	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	11- 6	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**16.7**	**50**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	151-15	400	1- 9	8	7- 0	23	18- 9	59	27-12	76	32- 2	77	29- 1	62	15- 9	30	3- 7	6	4- 1	6	0-11	1	0
1913	83-15	183	0- 0	0	0- 0	0	0-14	3	3- 2	9	3-11	9	3-10	8	3- 2	6	6- 8	11	10- 5	16	13- 1	17	0
1914	133-10	311	2-13	14	7- 1	24	12- 8	37	17-13	46	27-15	63	28-15	58	13- 9	24	9- 6	15	5-10	8	4- 3	5	0
1915	170-15	355	1- 4	6	3-15	13	14- 9	41	16- 7	41	26-13	60	34-13	69	22- 8	40	10-12	31	9-11	14	9-13	12	7
Average	**135.1**	**312**	**1.4**	**7**	**4.5**	**16**	**11.6**	**35**	**16.3**	**43**	**22.6**	**52**	**24.1**	**49**	**13.7**	**25**	**9.8**	**16**	**7.4**	**11**	**6.9**	**9**	**2**

404. Thomson strain:																								
Orchard grade—																								
1912	89– 5	335	42– 3	181	29–11	104	8– 4	25	8–12	25	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	68– 4	200	3–10	14	10–14	38	25– 0	76	17– 7	47	6–15	16	4– 6	9	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1914	120–15	349	6– 2	28	21–14	75	35– 7	105	31–14	84	20– 5	47	3– 1	6	2– 4	4	0– 0	0	0– 0	0	0– 0	0	....
1915	152–12	484	7–13	36	31–12	120	52– 4	167	28–12	82	22–11	58	8– 0	18	1– 8	3	0– 0	0	0– 0	0	0– 0	0	....
Average	**107.8**	**342**	**14.9**	**65**	**23.5**	**84**	**30.2**	**93**	**21.7**	**60**	**12.6**	**31**	**3.9**	**8**	**0.9**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	....
Standard grade—																								
1912	29– 9	160	27– 6	153	1– 2	4	0–10	2	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	16–11	63	8– 0	35	5– 0	17	2– 5	7	1– 6	4	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1914	15– 9	57	3– 8	22	4– 2	14	4– 8	13	2– 0	5	0– 7	1	1– 0	2	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1915	25–15	108	11– 4	57	10– 2	37	3– 2	10	1– 1	3	0– 6	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
Average	**21.9**	**97**	**12.5**	**67**	**5.1**	**18**	**2.6**	**8**	**1.2**	**3**	**0.2**	**0.5**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	....
Cull fruits—																								
1912	4– 2	24																					....
1913	6– 8	31																					....
1914	3– 4	14																					....
1915	2– 6	13																					....
Average	**4.1**	**21**																					....
Total crop—																								
1912	123– 0	520	69– 9	334	30–13	108	8–14	27	9– 3	26	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	6
1913	91– 7	294	11–10	49	15–14	55	27– 5	83	18–13	51	6–15	16	4– 6	9	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0
1914	139–12	420	9–10	50	23– 0	89	39–15	118	33–14	89	20–12	48	4– 1	8	2– 4	4	0– 0	0	0– 0	0	0– 0	0	0
1915	181– 1	605	19– 1	93	41–14	157	55– 6	177	29–13	85	23– 1	59	8– 0	18	1– 8	3	0– 0	0	0– 0	0	0– 0	0	15
Average	**133.8**	**460**	**27.5**	**132**	**28.6**	**102**	**32.9**	**101**	**22.9**	**63**	**12.8**	**31**	**4.1**	**9**	**0.9**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
408. Washington strain:																								
Orchard grade—																								
1912	148– 4	450	28– 8	115	36–14	121	22– 9	66	37–12	98	13–12	32	7–11	16	1– 2	2	0– 0	0	0– 0	0	0– 0	0	....
1913	132– 1	379	13– 8	64	16– 6	59	31– 9	96	18– 9	50	24– 6	57	16– 2	33	7– 2	13	3– 2	5	1– 5	2	0– 0	0	....
1914	85– 3	196	0– 4	1	3–11	12	12–11	36	16– 5	41	28– 3	62	19–12	37	3–10	6	0– 0	0	0–11	1	0– 0	0	....
1915	26–10	57	0– 0	0	0– 4	1	1– 6	4	1–13	5	6–12	16	7–13	16	6–13	12	1– 2	2	0– 0	0	0–11	1	....
Average	**98.0**	**271**	**10.5**	**45**	**14.3**	**48**	**17.0**	**51**	**18.6**	**49**	**18.3**	**42**	**12.8**	**26**	**4.7**	**8**	**1.1**	**2**	**0.5**	**0.8**	**0.2**	**0.3**	....
Standard grade—																								
1912	22– 1	91	12– 7	63	3–12	12	0–11	3	3– 1	8	1–11	4	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1913	24–14	80	6– 4	29	6– 9	23	5– 3	15	0–12	2	2– 3	4	1– 8	3	1– 2	2	1– 5	2	0– 0	0	0– 0	0	....
1914	15–10	49	4– 8	22	1– 9	5	3– 8	9	2– 2	5	1– 6	3	2– 0	4	0– 0	0	0– 9	1	0– 0	0	0– 0	0	....
1915	37–11	75	0– 2	1	0– 4	1	1– 0	3	1– 3	3	1–10	4	13– 4	29	6– 1	12	5– 5	9	4– 6	7	4– 8	6	....
Average	**25.1**	**74**	**5.8**	**29**	**3.0**	**10**	**2.6**	**8**	**1.8**	**5**	**1.7**	**4**	**4.3**	**9**	**1.8**	**4**	**1.8**	**3**	**1.1**	**2**	**1.1**	**2**	....

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Number
408. Washington strain—Con. Cull fruits—																							
1912	5- 4	30																					
1913	14-10	55																					
1914	3- 4	18																					
1915	4-10	13																					
Average	**6.9**	**29**																					
Total crop—																							
1912	175- 9	571	40-15	178	40-10	133	23- 4	69	40-13	106	15- 7	36	8- 2	17	1- 2	2	0- 0	0	0- 0	0	0- 0	0	1
1913	171- 9	514	19-12	93	22-15	82	35-12	111	19- 5	52	26- 9	61	17-10	36	8- 4	15	4- 7	7	1- 5	2	0- 0	0	1
1914	104- 1	263	4-12	23	5- 4	17	16- 3	45	18- 7	46	29- 9	65	21-12	41	3-10	6	0- 9	1	0-11	1	0- 0	0	1
1915	68-15	145	0- 2	1	0- 8	2	2- 6	7	3- 0	8	8- 6	20	21- 1	45	12-14	24	6- 7	11	4- 6	7	5- 3	7	1
Average	**130.0**	**373**	**16.4**	**74**	**17.3**	**59**	**19.6**	**58**	**20.4**	**53**	**20.0**	**46**	**17.1**	**35**	**6.5**	**12**	**2.9**	**5**	**1.6**	**3**	**1.3**	**2**	**1**
412. Wrinkled Australian strain:																							
Orchard grade—																							
1912	89- 3	237	9-14	37	17- 2	51	15-10	42	20-13	52	15- 2	34	8-14	18	1- 2	2	0-10	1	0- 0	0	0- 0	0	....
1913	41- 2	126	3-10	16	8-14	32	12- 2	37	9- 0	24	4- 2	10	2-14	6	0- 8	1	0- 0	0	0- 0	0	0- 0	0	....
1914	9- 9	27	0-12	3	0-10	2	1-12	5	1- 5	12	2- 2	5	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	8- 6	18	0- 0	0	0- 0	0	0- 0	0	1- 2	3	1-10	4	3- 0	6	2- 1	4	0- 9	1	0- 0	0	0- 0	0	....
Average	**37.1**	**102**	**3.6**	**14**	**6.7**	**21**	**7.4**	**21**	**8.8**	**23**	**5.8**	**13**	**3.7**	**8**	**0.9**	**2**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	....
Standard grade—																							
1912	58- 0	196	3- 7	55	8-10	27	11- 5	32	19- 4	49	9-13	22	5- 0	10	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1913	78- 0	310	33-12	165	17- 6	68	16-12	51	5-15	16	2-14	7	1- 5	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	115- 4	249	3- 0	16	5- 0	16	19- 2	53	11- 3	28	27- 4	61	21- 4	42	24-12	27	3- 0	5	0-11	1	0- 0	0	....
1915	59-15	145	1- 4	6	1-12	6	6-10	20	9- 6	25	12- 8	31	19- 3	41	5- 8	10	1- 2	2	2-10	4	0- 0	0	....
Average	**77.8**	**225**	**10.4**	**61**	**8.2**	**29**	**13.5**	**39**	**11.4**	**30**	**13.1**	**30**	**11.7**	**24**	**7.7**	**10**	**1.0**	**2**	**0.8**	**1**	**0**	**0**	....

Cull fruits—																								
1912	11- 5	46																						
1913	23- 2	96																						
1914	5-15	29																						
1915	4- 2	12																						
Average	**11.1**	**46**																						
Total crop—																								
1912	158- 8	479	13- 5	92	25-12	78	26-15	74	40- 1	101	24-15	56	13-14	28	1-11	3	0-10	1	0- 0	0	0- 0	0	134	
1913	142- 4	532	37- 6	181	26- 4	100	28-14	88	14-15	40	7- 0	17	4- 3	9	0- 8	1	0- 0	0	0- 0	0	0- 0	0	300	
1914	130-12	305	3-12	19	5-10	18	20-14	58	15- 8	40	29- 6	66	21- 4	42	24-12	27	3- 0	5	0-11	1	0- 0	0	259	
1915	72- 7	175	1- 4	6	1-12	6	6-10	20	10- 8	28	14- 2	35	22- 3	47	7- 9	14	1-11	3	2-10	4	0- 0	0	146	
Average	**126.0**	**373**	**13.9**	**75**	**14.8**	**51**	**20.8**	**60**	**20.3**	**52**	**18.9**	**44**	**15.4**	**32**	**8.6**	**11**	**1.3**	**2**	**0.8**	**1**	**0**	**0**	**210**	
418. Yellow Washington strain:																								
Orchard grade—																								
1912	85-14	230	0- 9	3	5- 2	19	21- 4	67	17-11	49	20- 1	49	13- 1	28	5-13	11	1-11	3	0-10	1	0- 0	0	....	
1913	62- 7	109	0- 0	0	0- 0	0	0- 5	1	1-14	5	4-12	11	4- 2	9	9-12	19	10- 6	19	14- 9	23	16-11	22	....	
1914	126-15	301	1-12	8	6- 5	22	16-12	49	21-13	57	27-11	65	26- 0	54	16- 5	30	6-12	11	2-13	4	0-12	1	....	
1915	101-15	194	0- 3	1	1- 3	4	4- 6	12	6- 9	16	13-15	31	24- 6	48	22- 2	40	12- 1	19	11- 7	' 16	5-11	7	....	
Average	**94.3**	**209**	**0.6**	**3**	**3.2**	**11**	**10.7**	**32**	**12.0**	**32**	**16.6**	**39**	**16.9**	**35**	**13.5**	**25**	**7.7**	**13**	**7.4**	**11**	**5.8**	**8**	....	
Standard grade—																								
1912	13-15	46	1- 7	8	1-13	8	3- 4	11	3- 7	10	2- 6	6	1- 0	2	0-10	1	0- 0	0	0- 0	0	0- 0	0	....	
1913	14-12	29	0- 0	0	0- 4	1	0- 0	0	1- 2	3	•3- 4	7	2-15	6	1-10	3	3-10	6	1- 4	2	0-11	1	....	
1914	16- 1	49	2-12	18	0- 4	1	1-11	5	5- 0	13	1- 7	3	3- 2	6	1- 3	2	0-10	1	0- 0	0	0- 0	0	....	
1915	20-14	41	0- 0	0	0- 4	1	0- 5	1	3- 7	8	4- 4	9	9- 7	17	0- 9	1	2-10	4	0- 0	0	0- 0	0	....	
Average	**16.4**	**41**	**1.1**	**7**	**0.6**	**3**	**1.3**	**4**	**3.2**	**9**	**2.8**	**6**	**4.1**	**8**	**1.0**	**2**	**1.7**	**3**	**0.3**	**0.5**	**0.1**	**0.3**	....	
Cull fruits—																								
1912	7- 9	33																						
1913	21-10	57																						
1914	1- 6	22																						
1915	5-13	14																						
Average	**9.1**	**31**																						
Total crop—																								
1912	107- 6	309	2- 0	11	6-15	27	24- 8	78	21- 2	59	22- 7	55	14- 1	30	6- 7	12	1-11	3	0-10	1	0- 0	0	0	
1913	98-13	195	0- 0	0	0- 4	1	0- 5	1	3- 0	8	8- 0	18	7- 1	15	11- 6	22	14- 0	25	15-13	25	17- 6	23	0	
1914	144- 6	372	4- 8	26	6- 9	23	18- 7	54	26-13	70	29- 2	68	29- 2	60	17- 8	32	7- 6	12	2-13	4	0-12	1	2	
1915	128-10	249	0- 3	1	1- 7	5	4-11	13	10- 0	24	18- 3	40	33-13	65	22-11	41	14-11	23	11- 7	16	5-11	7	8	
Average	**119.8**	**281**	**1.7**	**10**	**3.8**	**14**	**12.0**	**36**	**15.2**	**40**	**19.5**	**45**	**21.0**	**43**	**14.5**	**27**	**9.4**	**16**	**7.7**	**11**	**5.9**	**8**	**3**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
419. Washington strain: Orchard grade—																							
1912	88- 8	269	21- 9	88	21- 3	68	10-15	31	18- 6	47	10- 2	23	3-15	8	1- 2	2	1- 4	2	0- 0	0	0- 0	0	....
1913	88- 7	301	24 11	121	15-10	57	20- 6	63	8- 8	22	9 13	23	6- 7	13	1-11	3	0-10	1	0-11	1	0- 0	0	....
1914	66 10	149	1- 2	5	1-14	7	7- 8	22	9 10	24	20- 8	45	14- 6	27	10- 3	17	0-11	1	0-12	1	0- 0	0	....
1915	85- 2	177	0- 0	0	1- 4	4	4 14	14	7-15	20	20- 6	47	21- 8	43	18-10	33	5- 9	9	3- 8	5	1- 8	2	....
Average	**82.2**	**225**	**11.8**	**54**	**10.0**	**34**	**10.9**	**33**	**11.1**	**28**	**15.2**	**35**	**11.6**	**23**	**7.9**	**14**	**2.0**	**3**	**1.2**	**2**	**0.4**	**0.5**	....
Standard grade—																							
1912	38- 0	144	19- 5	93	6- 2	19	3-15	12	5- 4	13	0-14	2	1-15	4	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1913	39 12	175	21- 3	125	5- 8	19	3- 2	9	2- 6	6	5- 1	11	2- 8	5	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	16-15	50	2 14	14	4- 2	13	1-12	5	3- 3	8	2- 4	5	1- 0	2	1-12	3	0- 0	0	0- 0	0	0- 0	0	....
1915	30-11	75	0- 3	1	1- 3	5	4-12	15	3- 0	8	5- 5	13	10- 2	22	2- 8	5	1- 2	2	2- 8	4	0- 0	0	....
Average	**31.3**	**111**	**10.9**	**58**	**4.2**	**14**	**3.4**	**10**	**3.5**	**9**	**3.4**	**8**	**3.9**	**8**	**1.2**	**2**	**0.3**	**0.5**	**0.6**	**1**	**0**	**0**	....
Cull fruits—																							
1912	6- 7	51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	14- 3	70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	1- 0	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	3- 0	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**6.2**	**35**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	132-15	464	40-14	181	27- 5	87	14-14	43	23-10	60	11- 0	25	5-14	12	1-11	3	1- 4	2	0- 0	0	0- 0	0	5
1913	142- 6	549	45-14	246	21- 2	76	23- 8	72	10-14	28	14-14	34	8-15	18	1-11	3	0-10	1	0-11	1	0- 0	0	0
1914	84- 9	207	4- 0	19	6- 0	20	9- 4	27	12-13	32	22-12	50	15- 6	29	11-15	20	0-11	1	0-12	1	0- 0	0	7
1915	118-13	261	0- 3	1	2- 7	9	9-10	29	10-15	28	25-11	60	31-10	65	21- 2	38	6-11	11	6-0	9	1- 8	.2	3
Average	**119.7**	**370**	**22.7**	**112**	**14.2**	**48**	**14.3**	**43**	**14.6**	**37**	**18.6**	**42**	**15.5**	**31**	**9.1**	**16**	**2.3**	**4**	**1.9**	**3**	**0.4**	**0.5**	**4**

420. Unproductive strain:																								
Orchard grade—																								
1912	128– 8	337	9– 0	35	23–13	73	15– 2	42	36– 5	92	26– 8	60	15– 0	30	1– 9	3	1– 3	2	0– 0	0	0– 0	0	....	
1913	59–13	165	3–14	16	5– 0	18	15– 8	46	17–11	46	12– 8	29	3– 7	7	1– 2	2	0–11	1	0– 0	0	0– 0	0	....	
1914	83– 7	179	0– 4	1	1– 8	5	6–14	19	16– 4	40	29– 4	62	17–10	33	10– 6	17	0–10	1	0–11	1	0– 0	0	....	
1915	85– 7	164	0– 0	0	0– 0	0	1–12	5	3–12	10	17– 4	39	18– 8	37	30– 6	53	8– 6	13	1– 4	2	4– 3	5	....	
Average	**89.3**	**211**	**3.3**	**13**	**7.6**	**24**	**9.8**	**28**	**18.5**	**47**	**21.4**	**48**	**13.6**	**27**	**10.9**	**19**	**2.7**	**4**	**0.5**	**0.8**	**1.0**	**1**	....	
Standard grade—																								
1912	24– 0	70	4–10	20	4– 2	13	3– 4	9	8– 0	20	1– 7	3	2– 0	4	0– 9	1	0– 0	0	0– 0	0	0– 0	0	....	
1913	26– 6	94	10– 9	47	7– 1	24	4–12	14	1– 2	3	1– 4	3	1– 0	2	0– 0	0	0–10	1	0– 0	0	0– 0	0	....	
1914	5– 5	20	1–14	11	0– 5	1	1–14	5	0–13	2	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1915	26–10	64	1– 4	6	0– 5	1	2– 6	7	1– 8	4	6–10	16	11– 8	25	1–11	3	0– 0	0	1– 6	2	0– 0	0	....	
Average	**20.6**	**62**	**4.6**	**21**	**3.0**	**10**	**3.1**	**9**	**2.9**	**7**	**2.4**	**6**	**3.6**	**8**	**0.6**	**1**	**0.2**	**0.3**	**0.3**	**0.5**	**0**	**0**	....	
Cull fruits—																								
1912	4– 8	16																					....	
1913	20– 4	80																					....	
1914	4– 8	26																					....	
1915	9– 0	22																					....	
Average	**9.6**	**36**																					....	
Total crop—																								
1912	157– 0	423	13–10	55	27–15	86	18– 6	51	44– 5	112	27–15	63	17– 0	34	2– 2	4	1– 3	2	0– 0	0	0– 0	0	9	
1913	106– 7	339	14– 7	63	12– 1	42	20– 4	60	18–13	49	13–12	32	4– 7	9	1– 2	2	1– 5	2	0– 0	0	0– 0	0	0	
1914	93– 4	225	2– 2	12	1–13	6	8–12	24	17– 1	42	29–11	63	17–10	33	10– 6	17	0–10	1	0–11	1	0– 0	0	0	
1915	121– 1	250	1– 4	6	0– 5	1	4– 2	12	5– 4	14	23–14	55	30– 0	62	32– 1	56	8– 6	13	2–10	4	4– 3	5	3	
Average	**119.4**	**309**	**7.9**	**34**	**10.5**	**24**	**12.9**	**37**	**21.4**	**54**	**23.8**	**53**	**17.3**	**35**	**11.4**	**20**	**2.9**	**5**	**0.8**	**1**	**1.0**	**1**	**3**	
433. Washington strain:																								
Orchard grade—																								
1912	98–10	227	1– 6	5	5– 8	17	9– 0	25	23– 0	57	26– 4	58	24– 2	49	1–12	3	7– 0	12	0–10	1	0– 0	0	....	
1913	84– 7	208	2– 0	8	7–10	26	15– 7	45	15– 1	39	15–15	36	18– 0	36	8– 4	15	0–10	1	0–11	1	0–13	1	....	
1914	92–14	224	1– 3	5	6– 2	20	16–14	49	18– 6	46	34– 0	74	10– 6	20	5– 5	9	0–10	1	0– 0	0	0– 0	0	....	
1915	59– 7	112	0– 0	0	0– 0	0	1– 1	3	2– 6	6	8–14	20	13–12	28	16–14	30	9– 7	15	5– 9	8	1– 8	2	....	
Average	**83.8**	**193**	**1.1**	**5**	**4.8**	**16**	**10.6**	**31**	**14.7**	**37**	**21.3**	**47**	**16.6**	**33**	**8.0**	**14**	**4.4**	**7**	**1.7**	**3**	**0.6**	**0.8**	....	
Standard grade—																								
1912	32–10	82	4–10	18	3– 0	9	2–10	7	8–11	21	6– 2	13	4–11	9	1– 2	2	1–12	3	0– 0	0	0– 0	0	....	
1913	32–10	94	5– 4	22	6–15	24	5– 8	16	3– 2	8	3– 6	8	5– 7	11	3– 0	5	0– 0	0	0– 0	0	0– 0	0	....	
1914	11–15	35	1– 8	7	2– 8	8	3– 4	9	2–12	7	0– 7	1	1– 8	3	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1915	6–12	13	0– 0	0	0– 0	0	0– 5	1	0– 6	1	0–14	2	1– 8	3	1–12	3	1– 4	2	0–11	1	0– 0	0	....	
Average	**21.0**	**56**	**2.8**	**12**	**3.1**	**10**	**2.9**	**8**	**3.7**	**9**	**2.7**	**6**	**3.3**	**7**	**1.5**	**3**	**0.8**	**1**	**0.2**	**0.3**	**0**	**0**	....	

TABLE V. *Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																					
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
433. Washington strain—Con.																							
Cull fruits—																							
1912	7- 6	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	9- 5	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	1- 2	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	4- 6	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**5.5**	**18**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	138-10	333	6- 0	23	8- 8	26	11-10	32	31-11	78	32- 6	71	28-13	58	2-14	5	8-12	15	0-10	1	0- 0	0	0
1913	125- 6	330	7- 4	30	14- 9	50	20-15	61	18- 3	47	19- 5	44	23- 7	47	11- 4	20	0-10	1	0-11	1	0-13	1	0
1914	105-15	261	2-11	12	8-10	28	20- 2	58	21- 2	53	34- 7	75	11-14	23	5- 5	9	0-10	1	0- 0	0	0- 0	0	0
1915	70- 9	140	0- 0	0	0- 0	0	1- 6	4	2-12	7	9-12	22	15- 4	31	18-10	33	10-11	17	6- 4	9	1- 8	2	1
Average	**110.4**	**257**	**4.0**	**16**	**7.9**	**26**	**13.5**	**39**	**18.4**	**46**	**24.0**	**53**	**19.8**	**40**	**9.5**	**17**	**5.2**	**9**	**1.9**	**3**	**0.6**	**0.8**	**0.3**
436. Unproductive strain:																							
Orchard grade—																							
1912	114- 7	355	29- 7	119	29- 7	96	15-10	45	26- 1	66	6-14	16	6- 0	12	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1913	85-13	289	25-13	122	13-13	50	20- 0	57	9-13	25	10-15	25	3-11	7	1-12	3	0- 0	0	0- 0	0	0- 0	0	....
1914	53- 1	117	0- 8	2	3- 6	11	9- 0	25	8-10	21	12- 4	26	11- 6	20	6- 8	10	1- 7	2	0- 0	0	0- 0	0	....
191	42- 9	97	0- 0	0	0-14	3	3- 6	10	9-14	25	14- 8	33	7- 6	15	2-12	5	3- 3	5	0-10	1	0- 0	0	....
Average	**74.0**	**215**	**13.9**	**61**	**12.0**	**40**	**12.0**	**34**	**13.6**	**34**	**11.1**	**25**	**7.1**	**14**	**2.9**	**5**	**1.2**	**2**	**0.2**	**0.3**	**0**	**0**	....
Standard grade—																							
1912	37-15	166	25- 7	130	5-11	18	2-13	8	2- 5	6	1-11	4	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	31-12	129	16- 3	82	6-12	23	5- 0	15	1- 9	4	1-12	4	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	13-11	38	1-15	10	3- 0	9	2-10	7	0- 7	1	2- 7	5	2-10	5	0-10	1	0- 0	0	0- 0	0	0- 0	0	....
1915	13- 2	33	1- 0	4	1-14	6	2- 2	6	0-12	2	1-12	4	4- 0	8	1-10	3	0- 0	0	0- 0	0	0- 0	0	...
Average	**24.1**	**92**	**11.1**	**57**	**4.3**	**14**	**3.1**	**9**	**1.3**	**3**	**1.9**	**4**	**1.8**	**4**	**0.6**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	....

Cull fruits—																								
1912	10-14	64																						
1913	20- 6	94																						
1914	3- 4	17																						
1915	1- 7	4																						
Average	**9.0**	**45**																						
Total crop—																								
1912	163- 4	585	54-14	249	35- 9	114	18- 7	53	28- 6	72	8- 9	20	6- 0	12	0- 9	1	0- 0	0	0- 0	0	0- 0	0	2	
1913	137-15	512	42- 0	204	20- 9	73	25- 0	72	11- 6	29	12-11	29	4- 3	8	1-12	3	0- 0	0	0- 0	0	0- 0	0	0	
1914	70- 0	172	2- 7	12	6- 6	20	11-10	32	9- 1	22	14-11	31	14- 0	25	7- 2	11	1- 7	2	0- 0	0	0- 0	0	6	
1915	57- 2	134	1- 0	4	2-12	9	5- 8	16	10-10	27	16- 4	37	11- 6	23	4- 6	8	3- 3	5	0-10	1	0- 0	0	0	
Average	**107.1**	**351**	**25.1**	**117**	**16.3**	**54**	**15.1**	**43**	**14.9**	**38**	**13.0**	**29**	**8.9**	**17**	**3.5**	**6**	**1.2**	**2**	**0.2**	**0.3**	**0**	**0**	**2**	
441, Yellow Washington strain; Orchard grade—																								
1912	71- 2	179	0- 0	0	2-14	11	11- 3	36	14- 9	40	14- 1	35	17- 8	37	7- 6	14	2- 4	4	0-10	1	0-11	1	....	
1913	28- 9	56	0- 0	0	0- 0	0	0- 5	1	0-11	2	3-12	9	5-15	13	4- 8	9	7-14	14	3-14	6	1-10	2	....	
1914	104- 8	241	0- 4	1	2- 2	7	11- 3	33	16- 7	43	25- 9	59	22- 2	45	14- 4	26	9- 1	15	1-15	10	1- 9	2	....	
1915	119- 4	259	0- 6	2	2- 6	8	13- 2	37	18- 0	45	28- 7	63	26- 0	52	16-13	30	9- 5	15	4- 1	6	0-12	1	....	
Average	**80.9**	**184**	**0.1**	**1**	**1.8**	**7**	**9.0**	**27**	**12.4**	**32**	**17.9**	**41**	**17.9**	**37**	**10.7**	**20**	**7.1**	**12**	**2.6**	**6**	**1.1**	**1**	....	
Standard grade—																								
1912	13-12	38	0-15	5	0- 5	1	2- 9	8	2-12	8	2-12	7	3- 6	7	0- 8	1	0- 9	1	0- 0	0	0- 0	0	....	
1913	7- 1	16	0- 0	0	0- 5	1	0- 5	1	0- 0	0	2- 8	6	3-15	8	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....	
1914	15- 3	41	1-12	10	1- 8	5	1-12	5	3-10	9	2- 6	5	1-10	3	0- 9	1	1- 5	2	0-11	1	0- 0	0	....	
1915	25- 7	62	0-12	4	0-13	3	3- 1	9	4- 5	11	11-13	26	3- 1	6	1- 1	2	0- 9	1	0- 0	0	0- 0	0	....	
Average	**15.3**	**39**	**0.9**	**5**	**0.8**	**3**	**1.9**	**6**	**2.7**	**7**	**4.9**	**11**	**3.0**	**6**	**0.5**	**1**	**0.6**	**1**	**0.2**	**0.3**	**0**	**0**	....	
Cull fruits—																								
1912	4- 5	60																						
1913	18- 8	56																						
1914	4-11	22																						
1915	6- 7	17																						
Average	**8.5**	**39**																						
Total crop—																								
1912	89- 3	277	0-15	5	3- 3	12	13-12	44	17- 5	48	16- 3	42	20-14	44	7-14	15	2-13	5	0-10	1	0-11	1	0	
1913	54- 2	128	0- 0	0	0- 5	1	0-10	2	0-11	2	6- 4	15	9-14	21	4- 8	9	7-14	14	3-14	6	1-10	2	0	
1914	124- 6	304	2- 0	11	3-10	12	12-15	38	20- 1	52	27-15	64	23-12	48	14-13	27	10- 6	17	2-10	11	1- 9	2	0	
1915	151- 2	338	1- 2	6	3- 3	11	16- 3	46	22- 5	56	40- 4	89	29- 1	58	17-14	32	9-14	16	4- 1	6	0-12	1	10	
Average	**104.7**	**262**	**1.0**	**6**	**2.6**	**9**	**10.9**	**32**	**15.1**	**39**	**22.8**	**52**	**20.9**	**43**	**11.3**	**21**	**7.7**	**13**	**2.8**	**6**	**1.1**	**2**	**3**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
444. Washington strain:																							
Orchard grade—																							
1912	112- 2	336	22-12	91	29- 9	94	15-10	44	29- 9	75	9- 2	21	4- 6	9	1- 2	2	0- 0	0	0- 0	0	0- 0	0	....
1913	84- 3	282	19- 2	94	17- 1	61	22- 8	67	11- 2	29	9- 7	22	3- 2	6	1- 3	2	0-10	1	0- 0	0	0- 0	0	....
1914	52- 8	120	1- 1	4	3-10	12	8-14	24	8- 2	20	16-10	35	10- 8	19	2- 5	4	1- 6	2	0- 0	0	0- 0	0	....
1915	32- 1	61	0- 0	0	0- 0	0	0-15	3	2- 3	6	6- 1	14	4-10	9	9- 4	16	3-12	6	2-14	4	2- 6	3	....
Average	**70.2**	**200**	**10.7**	**47**	**12.3**	**42**	**12.0**	**35**	**12.8**	**33**	**10.3**	**23**	**5.7**	**11**	**3.5**	**6**	**1.4**	**2**	**0.7**	**1**	**0.6**	**0.8**	....
Standard grade—																							
1912	26-13	109	15- 9	78	4- 1	13	1-11	5	3-12	9	1- 4	3	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	30-13	125	13-10	75	5- 6	19	6-14	20	1- 2	3	2- 4	5	1- 9	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	9-11	28	1-14	9	1- 8	5	2- 6	6	0-12	2	2- 0	4	0- 9	1	0-10	1	0- 0	0	0- 0	0	0- 0	0	....
1915	25- 6	65	0-10	4	1-10	6	2- 8	8	2-10	7	6-14	17	6-12	15	3- 4	6	1- 2	2	0- 0	0	0- 0	0	....
Average	**23.2**	**82**	**7.9**	**42**	**3.1**	**11**	**3.4**	**10**	**2.1**	**5**	**3.1**	**7**	**2.3**	**5**	**1.0**	**2**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	....
Cull fruits—																							
1912	7-15	49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	18- 5	89	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	3- 0	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	2- 0	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**7.8**	**40**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	146-14	494	38- 5	169	33-10	107	17- 5	49	33- 5	84	10- 6	24	4-14	10	1- 2	2	0- 0	0	0- 0	0	0- 0	0	10
1913	133- 5	496	32-12	169	22- 7	80	29- 6	87	12- 4	32	11-11	27	4-11	9	1- 3	2	0-10	1	0- 0	0	0- 0	0	0
1914	65- 3	159	2-15	13	5- 2	17	11- 4	30	8-14	22	18-10	39	11- 1	20	2-15	5	1- 6	2	0- 0	0	0- 0	0	3
1915	59- 7	136	0-10	4	1-10	6	3- 7	11	4-13	13	12-15	31	11- 6	24	12- 8	22	4-14	8	2-14	4	2- 6	3	0
Average	**101.2**	**321**	**18.7**	**89**	**15.7**	**53**	**15.3**	**44**	**14.8**	**38**	**13.4**	**30**	**8.0**	**16**	**4.4**	**8**	**1.7**	**3**	**0.7**	**1**	**0.6**	**0.8**	**3**

446. Unproductive strain:																							
Orchard grade—																							
1912	114-13	35	27-12	113	27- 8	88	14-13	42	26- 8	69	10-14	25	5-10	11	1- 3	2	0- 9	1	0- 0	0	0- 0	0	....
1913	78-11	277	22- 8	109	16- 2	58	21-12	66	9- 0	24	5- 8	13	2- 9	5	0- 9	1	0-11	1	0- 0	0	0- 0	0	....
1914	54-11	123	0-12	3	5- 4	17	6- 3	17	8- 4	20	15- 8	33	13-10	25	4- 5	7	0- 0	0	0- 0	0	0-13	1	....
1915	26-15	55	0- 0	0	0- 4	1	1-11	5	2- 7	6	8-10	19	3- 8	7	7-12	13	2- 0	3	0-11	1	0- 0	0	....
Average	**68.8**	**202**	**12.8**	**56**	**12.3**	**41**	**11.1**	**33**	**11.5**	**30**	**10.1**	**23**	**6.3**	**12**	**3.5**	**6**	**0.8**	**1**	**0.2**	**0.3**	**0.2**	**0.3**	....
Standard grade—																							
1912	37-13	162	26-4	129	6-14	21	1-14	5	1- 7	4	0-14	2	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	36- 9	177	24-0	137	5-10	20	3- 9	11	2- 2	6	1- 4	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	14-15	49	4-8	23	2- 0	6	3- 0	8	1-12	4	3- 2	7	0- 0	0	0- 9	1	0- 0	0	0- 0	0	0- 0	0	....
1915	10- 6	26	0-2	1	0- 9	2	2- 5	7	0- 6	1	2- 0	5	2-13	6	1-10	3	0- 9	1	0- 0	0	0- 0	0	....
Average	**24.9**	**103**	**13.7**	**73**	**3.8**	**12**	**2.7**	**8**	**1.4**	**4**	**1.8**	**4**	**0.8**	**2**	**0.5**	**1**	**0.1**	**0.3**	**0**	**0**	**0**	**0**	....
Cull fruits—																							
1912	7-12	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1913	14-15	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1914	1-10	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1915	0-14	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Average	**6.3**	**38**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Total crop—																							
1912	160- 6	571	54- 0	242	34- 6	109	16-11	47	27-15	73	11-12	27	6- 2	12	1- 3	2	0- 9	1	0- 0	0	0- 0	0	10
1913	130- 3	534	46- 8	246	21-12	78	25- 5	77	11- 2	30	6-12	16	2- 9	5	0- 9	1	0-11	1	0- 0	0	0- 0	0	3
1914	71- 4	183	5- 4	26	7- 4	23	9- 3	25	10- 0	24	18-10	40	13-10	25	4-14	8	0- 0	0	0- 0	0	0-13	1	5
1915	38- 3	84	0- 2	1	0-13	3	4- 0	12	2-13	7	10-10	24	6- 5	13	9- 6	16	2- 9	4	0-11	1	0- 0	0	0
Average	**100.0**	**343**	**26.5**	**129**	**16.0**	**53**	**13.8**	**40**	**13.0**	**34**	**11.9**	**27**	**7.2**	**14**	**4.0**	**7**	**1.0**	**2**	**0.2**	**0.3**	**0.2**	**0.3**	**5**
456. Unproductive strain:																							
Orchard grade—																							
1912	112-14	333	19- 7	76	28-10	93	18- 2	52	27-14	72	9- 2	21	5-12	12	1- 1	2	2-14	5	0- 0	0	0- 0	0	....
1913	75- 7	246	13-15	80	11- 0	41	15- 2	46	11- 9	31	15- 2	35	4-15	10	1- 2	2	0-10	1	0- 0	0	0- 0	0	....
1914	53- 9	128	0-12	3	5-14	19	9-10	27	11- 2	27	13- 0	28	9-15	19	2-10	4	0-10	1	0- 0	0	0- 0	0	....
1915	25- 4	58	0- 0	0	0- 0	0	2- 4	7	4- 4	11	8-10	20	5-11	12	3- 4	6	0- 9	1	0-10	1	0- 0	0	....
Average	**66.8**	**191**	**9.0**	**40**	**11.4**	**38**	**11.3**	**33**	**13.7**	**35**	**11.5**	**26**	**6.6**	**13**	**2.0**	**4**	**1.2**	**2**	**0.2**	**0.3**	**0**	**0**	....
Standard grade—																							
1912	29-12	128	20- 1	99	3- 2	10	2-15	10	1- 8	4	2- 2	5	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	25-12	118	15- 3	86	4- 9	16	3- 3	9	1- 9	4	1- 4	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	14- 0	47	5- 8	24	3- 6	11	2- 9	7	0-13	2	0- 0	0	0- 8	1	1- 4	2	0- 0	0	0- 0	0	0- 0	0	....
1915	12- 9	32	0- 0	0	0-14	3	2-11	8	2-12	7	1-12	4	4- 8	10	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
Average	**20.5**	**81**	**10.2**	**52**	**3.0**	**10**	**2.8**	**9**	**1.7**	**4**	**1.3**	**3**	**1.3**	**3**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	....

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
456. Unproductive strain—Continued.																							
Cull fruits—																							
1912	3–14	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	9–13	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	1–6	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	1–10	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**4.2**	**22**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	146– 8	483	39– 8	175	31–12	103	21– 1	62	29– 6	76	11– 4	26	5–12	12	1– 1	2	2–14	5	0– 0	0	0– 0	0	4
1913	111– 0	412	31– 2	166	15– 9	57	18– 5	55	13– 2	35	16– 6	38	4–15	10	1– 2	2	0–10	1	0– 0	0	0– 0	0	0
1914	68–15	185	6– 4	27	9– 4	30	12– 3	34	11–15	29	13– 0	28	10– 7	20	3–14	6	0–10	1	0– 0	0	0– 0	0	1
1915	39– 7	96	0– 0	0	0–14	3	4–15	15	7– 0	18	10– 6	24	10– 3	22	3– 4	6	0– 9	1	0–10	1	0– 0	0	0
Average	**91.5**	**294**	**19.2**	**92**	**14.3**	**48**	**14.1**	**42**	**15.4**	**40**	**12.8**	**29**	**7.8**	**16**	**2.3**	**4**	**1.2**	**2**	**0.2**	**0.3**	**0**	**0**	**1**
457. Yellow Washington strain: Orchard grade—																							
1912	36– 8	93	0– 3	1	1– 9	6	5– 0	16	10– 0	27	7– 2	17	7–15	17	4– 2	8	0– 9	1	0– 0	0	0– 0	0	.....
1913	14– 7	28	0– 0	0	0– 0	0	0– 0	0	0–12	2	2–14	7	0–13	2	1– 9	3	3– 5	6	3–12	6	1– 6	2	.....
1914	99– 6	230	0–15	4	4–12	16	12–12	37	18– 0	46	22–11	52	20– 3	41	12–13	23	4– 4	7	1– 7	2	1– 9	2	.....
1915	86– 0	170	0– 3	1	1– 7	5	5– 3	15	8– 8	21	13– 0	28	17– 9	35	17– 0	30	15– 1	24	4–15	7	3– 2	4	.....
Average	**59.1**	**130**	**0.3**	**2**	**1.9**	**7**	**5.7**	**17**	**9.3**	**24**	**11.4**	**26**	**11.6**	**24**	**8.9**	**16**	**5.8**	**10**	**2.5**	**4**	**1.5**	**2**	.....
Standard grade—																							
1912	16–13	45	0– 7	3	0– 8	2	1– 3	4	5– 5	15	5– 5	13	2– 6	5	1–11	3	0– 0	0	0– 0	0	0– 0	0	.....
1913	8–14	15	0– 0	0	0– 0	0	0– 0	0	0–12	2	1– 6	3	0– 8	1	2– 7	4	0–11	1	3– 2	4	0– 0	0	.....
1914	11–13	29	0– 2	1	1– 4	4	2– 2	6	3– 4	8	2–13	6	1– 1	2	0– 9	1	0–10	1	0– 0	0	0– 0	0	.....
1915	22–14	49	0– 2	1	0– 0	0	1–11	5	4– 0	10	7– 6	16	5–12	11	2– 7	4	0– 0	0	0–12	1	0–12	1	.....
Average	**15.1**	**35**	**0.2**	**1**	**0.4**	**1**	**1.3**	**4**	**3.3**	**9**	**4.2**	**10**	**2.4**	**5**	**1.8**	**3**	**0.3**	**0.5**	**1.0**	**1**	**0.2**	**0.3**	.....

Cull fruits—																								
1912	13– 0	38																						
1913	34– 8	80																						
1914	2– 9	9																						
1915	9–13	24																						
Average	**15.0**	**38**																						
Total crop—																								
1912	66– 5	176	0–10	4	2– 1	8	6– 3	20	15– 5	42	12– 7	30	10– 5	22	5–13	11	0– 9	1	0– 0	0	0– 0	0	0	
1913	57–13	123	0– 0	0	0– 0	0	0– 0	0	1– 8	4	4– 4	10	1– 5	3	4– 0	7	4– 0	7	6–14	10	1– 6	2	0	
1914	113–12	268	1– 1	5	6– 0	20	14–14	43	21– 4	54	25– 8	58	21– 4	43	13– 6	24	4–14	8	1– 7	2	1– 9	2	0	
1915	118–11	243	0– 5	2	1– 7	5	6–14	20	12– 8	31	20– 6	44	23– 5	46	19– 7	34	15– 1	24	5–11	8	3–14	5	7	
Average	**89.2**	**203**	**0.5**	**3**	**2.4**	**8**	**7.0**	**21**	**12.6**	**33**	**15.7**	**36**	**14.1**	**28**	**10.6**	**19**	**6.1**	**10**	**3.5**	**5**	**1.7**	**2**	**2**	
465. Unproductive strain: Orchard grade—																								
1912	98– 2	188	0– 5	1	2– 7	7	2–14	8	10–14	26	13– 3	29	28– 0	54	4– 8	8	25–15	43	10– 0	12	0– 0	0	....	
1913	45–15	114	1– 3	5	3–14	13	8–12	25	9– 1	23	13– 6	30	6– 2	12	2–14	5	0– 0	0	0–11	1	0– 0	0	....	
1914	54– 2	103	0– 0	0	0– 0	0	0– 6	1	6– 6	15	16– 1	33	15–10	29	14– 4	23	1– 7	2	0– 0	0	0– 0	0	....	
1915	60– 3	103	0– 0	0	0– 0	0	0– 0	0	2– 1	5	6– 8	14	9– 2	18	21–12	37	10– 0	15	5–13	8	4–15	6	....	
Average	**64.6**	**127**	**0.4**	**2**	**1.6**	**5**	**3.0**	**9**	**7.1**	**17**	**12.3**	**27**	**14.7**	**28**	**10.8**	**18**	**9.3**	**15**	**4.1**	**5**	**1.2**	**2**	....	
Standard grade—																								
1912	12–12	29	0– 8	2	0– 6	1	0–12	2	4–10	11	3– 4	7	1– 8	3	0– 0	0	1–12	3	0– 0	0	0– 0	0	....	
1913	14– 8	47	4– 6	18	3– 4	11	3–10	10	0–12	2	2– 8	6	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1914	6– 7	16	0– 6	2	0– 5	1	1– 6	4	0– 0	0	1– 6	3	3– 0	6	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1915	6–13	13	0– 0	0	0– 0	0	0– 5	1	0– 0	0	1– 4	3	2– 0	4	0– 9	1	0–10	1	2– 1	3	0– 0	0	....	
Average	**10.1**	**26**	**1.3**	**6**	**1.0**	**3**	**1.5**	**4**	**1.3**	**3**	**2.1**	**5**	**1.6**	**3**	**0.1**	**0.3**	**0.6**	**1**	**0.5**	**0.8**	**0**	**0**	....	
Cull fruits—																								
1912	10– 6	31																						
1913	3– 0	12																						
1914	1–12	5																						
1915	7– 2	15																						
Average	**5.6**	**16**																						
Total crop—																								
1912	121– 4	248	0–13	3	2–13	8	3–10	10	15– 8	37	16– 7	36	29– 8	57	4– 8	8	27–11	46	10– 0	12	0– 0	0	0	
1913	63– 7	173	5– 9	23	7– 2	24	12– 6	35	9–13	25	15–14	36	6– 2	12	2–14	5	0– 0	0	0–11	1	0– 0	0	0	
1914	62– 5	124	0– 6	2	0– 5	1	1–12	5	6– 6	15	17– 7	36	18–10	35	14– 4	23	1– 7	2	0– 0	0	0– 0	0	3	
1915	74– 2	131	0– 0	0	0– 0	0	0– 5	1	2– 1	5	7–12	17	11– 2	22	22– 5	38	10–10	16	7–14	11	4–15	6	1	
Average	**80.3**	**169**	**1.7**	**7**	**2.6**	**8**	**4.5**	**13**	**8.4**	**21**	**14.4**	**31**	**16.3**	**32**	**11.0**	**19**	**9.9**	**16**	**4.6**	**6**	**1.2**	**2**	**1**	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																				Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
475. Unproductive strain:																							
Orchard grade—																							
1912	48- 2	146	8-14	34	17- 1	55	8- 4	23	8- 6	21	4- 2	10	1- 7	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	63- 1	178	7- 0	31	8- 2	28	17-11	51	8-14	23	12- 4	28	5-10	11	2-14	5	0-10	1	0- 0	0	0- 0	0	....
1914	43- 0	110	1- 6	5	4- 3	14	9-14	28	10- 3	26	10- 2	23	6- 2	12	1- 2	2	0- 0	0	0- 0	0	0- 0	0	....
1915	57- 6	134	0- 4	1	1- 8	5	4-14	14	15- 4	39	18-10	43	5-12	12	8- 8	16	0- 9	1	1- 6	2	0-11	1	....
Average	**52.9**	**142**	**4.4**	**18**	**7.7**	**26**	**10.2**	**29**	**10.7**	**27**	**11.3**	**26**	**4.7**	**10**	**3.1**	**6**	**0.3**	**0.5**	**0.3**	**0.5**	**0.2**	**0.3**	....
Standard grade—																							
1912	15- 1	58	9- 4	40	4- 1	13	0-15	3	0- 6	1	0- 7	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1913	14- 6	52	4- 7	23	4- 2	14	2- 8	7	2-13	7	0- 0	0	0- 8	1	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1914	10- 6	32	3- 1	13	1-14	6	2- 3	6	0-13	2	1- 7	3	1- 0	2	0- 0	0	0- 0	0	0- 0	0	0- 0	0	....
1915	19-10	50	1- 8	6	1-12	6	1-10	5	2- 3	6	3- 8	9	5- 2	11	2- 2	4	0- 9	1	0- 9	1	0-11	1	....
Average	**14.9**	**48**	**4.6**	**21**	**3.0**	**10**	**1.8**	**5**	**1.5**	**4**	**1.3**	**3**	**1.7**	**4**	**0.5**	**1**	**0.1**	**0.3**	**0.1**	**0.3**	**0.2**	**0.3**	....
Cull fruits—																							
1912	3- 2	13																					....
1913	9- 8	36																					....
1914	6- 3	31																					....
1915	3- 8	12																					....
Average	**5.6**	**23**																					....
Total crop—																							
1912	66- 5	217	18- 2	74	21- 2	68	9- 3	26	8-12	22	4- 9	11	1- 7	3	0- 0	0	0- 0	0	0- 0	0	0- 0	0	5
1913	86-15	266	11- 7	54	12- 4	42	20- 3	58	11-11	30	12- 4	28	6- 2	12	2-14	5	0-10	1	0- 0	0	0- 0	0	0
1914	59- 9	173	4- 7	18	6- 1	20	12- 1	34	11- 0	28	11- 9	26	7- 2	14	1- 2	2	0- 0	0	0- 0	0	0- 0	0	4
1915	80- 8	196	1-12	7	3- 4	11	6- 8	19	17- 7	45	22- 2	52	10-14	23	10-10	20	1- 2	2	1-15	3	1- 6	2	0
Average	**73.3**	**213**	**8.9**	**38**	**10.7**	**35**	**12.0**	**34**	**12.2**	**31**	**12.6**	**29**	**6.4**	**13**	**3.7**	**7**	**0.4**	**0.8**	**0.5**	**0.8**	**0.3**	**0.5**	**2**

477. Unproductive strain:																								
Orchard grade—																								
1912	67–13	129	0–11	3	0–11	2	1– 2	3	8– 1	19	10–10	22	23– 5	43	2–14	5	14–12	24	4–15	7	0–12	1	....	
1913	18–15	51	0–12	3	1– 3	4	8– 3	24	2–12	7	4– 7	10	1– 1	2	0– 9	1	0– 0	0	0– 0	0	0– 0	0	....	
1914	17–12	34	0– 4	1	0– 5	1	0– 0	0	0–12	2	6–15	14	5– 2	9	4– 6	7	0– 0	0	0– 0	0	0– 0	0	....	
1915	73– 4	131	0– 0	0	0– 4	1	0–11	2	2–12	7	13– 0	28	17– 1	32	21– 1	35	12– 2	18	3– 0	4	3– 5	4	....	
Average	**44.4**	**86**	**0.4**	**2**	**0.6**	**2**	**2.5**	**7**	**3.6**	**9**	**8.8**	**19**	**11.6**	**22**	**7.2**	**12**	**6.7**	**11**	**2.0**	**3**	**1.0**	**1**	....	
Standard grade—																								
1912	10–10	25	0– 8	2	0–11	2	1–13	5	1– 3	3	3– 4	7	2– 9	5	0– 0	0	0–10	1	0– 0	0	0– 0	0	....	
1913	9–12	29	2– 5	10	0–14	3	3– 0	8	0–12	2	2– 5	5	0– 8	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
1914	0–15	2	0– 0	0	0– 0	0	0– 5	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0–10	1	0– 0	0	0– 0	0	....	
1915	13–10	28	0– 0	0	0– 0	0	1– 7	4	0–12	2	3– 7	8	3– 0	6	2– 3	4	1–10	3	0– 0	0	1– 3	1	....	
Average	**8.7**	**21**	**0.7**	**3**	**0.4**	**1**	**1.6**	**5**	**0.7**	**2**	**2.3**	**5**	**1.5**	**3**	**0.5**	**1**	**0.7**	**1**	**0**	**0**	**0.3**	**0.3**	....	
Cull fruits—																								
1912	7– 0	24																						
1913	11– 4	29																						
1914	1– 0	6																						
1915	7– 5	20																						
Average	**6.6**	**20**																						
Total crop—																								
1912	85– 7	178	1– 3	5	1– 6	4	2–15	8	9– 4	22	13–14	29	25–14	48	2–14	5	15– 6	25	4–15	7	0–12	1	4	
1913	39–15	109	3– 1	13	2– 1	7	11– 3	32	3– 8	9	6–12	15	1– 9	3	0– 9	1	0– 0	0	0– 0	0	0– 0	0	0	
1914	19–11	42	0– 4	1	0– 5	1	0– 5	1	0–12	2	6–15	14	5– 2	9	4– 6	7	0–10	1	0– 0	0	0– 0	0	2	
1915	94– 3	179	0– 0	0	0– 4	1	2– 2	6	3– 8	9	16– 7	36	20– 1	38	23– 4	39	13–12	21	3– 0	4	4– 8	5	0	
Average	**59.8**	**127**	**1.1**	**5**	**1.0**	**3**	**4.1**	**12**	**4.3**	**11**	**11.0**	**24**	**13.2**	**25**	**7.8**	**13**	**7.4**	**12**	**2.0**	**3**	**1.3**	**2**	**1**	
478. Yellow Washington strain:																								
Orchard grade—																								
1912	41– 0	99	0– 0	0	0– 7	2	3– 2	10	9– 9	26	13– 0	31	6– 7	14	6–12	13	1– 1	2	0–10	1	0– 0	0	....	
1913	6– 6	12	0– 0	0	0– 0	0	0– 6	1	0– 0	0	0– 0	0	0–15	2	1– 8	3	1–12	3	1–13	3	0– 0	0	....	
1914	71–12	172	1– 4	5	3–14	13	10–13	31	16– 8	42	16– 0	37	12–12	26	6– 0	11	1–14	3	2–11	4	0– 0	0	....	
1915	31– 2	60	0– 0	0	0– 0	0	1– 0	3	3– 5	8	3–10	8	11– 4	22	5– 3	9	3–12	6	2– 3	3	0–13	1	....	
Average	**37.6**	**86**	**0.3**	**1**	**1.1**	**4**	**3.8**	**11**	**7.3**	**19**	**8.2**	**19**	**7.8**	**16**	**4.9**	**9**	**2.1**	**4**	**1.8**	**3**	**0.2**	**0.3**	....	
Standard grade—																								
1912	9– 5	25	0– 0	0	0– 0	0	1– 2	4	2– 1	6	5– 2	13	0– 8	1	0– 8	1	0– 0	0	0– 0	0	0– 0	0	....	
1913	3– 2	7	0– 0	0	0– 0	0	0– 0	0	1– 8	4	0– 7	1	0– 0	0	1– 3	2	0– 0	0	0– 0	0	0– 0	0	....	
1914	9–13	25	0–10	3	0–15	3	1– 6	4	3– 4	8	1–14	4	0– 9	1	0– 9	1	0–10	1	0– 0	0	0– 0	0	....	
1915	18– 7	41	0– 3	1	0– 8	2	3– 1	8	3– 4	8	4– 4	9	7– 3	13	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....	
Average	**10.2**	**25**	**0.2**	**1**	**0.4**	**1**	**1.4**	**4**	**2.5**	**7**	**2.9**	**7**	**2.1**	**4**	**0.6**	**1**	**0.2**	**0.3**	**0**	**0**	**0**	**0**	....	

TABLE V.—*Detailed statement of the annual performance of 64 representative Washington Navel orange trees for which records were obtained for four years, 1912 to 1915, inclusive, as summarized in Table IV*—Continued.

Rank in Table IV, strain, grade, and year.	Sizes.																						Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	
478. Yellow Washington strain—Continued.																							
Cull fruits—																							
1912	10–10	32																					
1913	18– 0	48																					
1914	2–12	10																					
1915	4– 6	12																					
Average	**8.9**	**26**																					
Total crop—																							
1912	60–15	156	0– 0	0	0– 7	2	4– 4	14	11–10	32	18– 2	44	6–15	15	7– 4	14	1– 1	2	0–10	1	0– 0	0	0
1913	27– 8	67	0– 0	0	0– 0	0	0– 6	1	1– 8	4	0– 7	1	0–15	2	2–11	5	1–12	3	1–13	3	0– 0	0	0
1914	84– 5	207	1–14	8	4–13	16	12– 3	35	19–12	50	17–14	41	13– 5	27	6– 9	12	2– 8	4	2–11	4	0– 0	0	0
1915	53–15	113	0– 3	1	0– 8	2	4– 1	11	6– 9	16	7–14	17	18– 7	35	5– 3	9	3–12	6	2– 3	3	0–13	1	2
Average	**56.7**	**136**	**0.5**	**2**	**1.4**	**5**	**5.2**	**15**	**9.9**	**26**	**11.1**	**26**	**9.9**	**20**	**5.4**	**10**	**2.3**	**4**	**1.8**	**3**	**0.2**	**0.3**	**0.5**
481. Unproductive strain:																							
Orchard grade—																							
1912	39– 0	81	0– 0	0	1– 0	3	1–14	5	8– 5	20	10– 0	22	9– 6	18	1–10	3	5– 1	8	1–12	2	0– 0	0	....
1913	19– 1	54	0–15	4	3– 5	12	5– 8	16	5– 9	14	2– 4	5	1– 8	3	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....
1914	41– 8	98	0– 4	1	2– 4	7	6–12	19	12– 0	29	14 12	32	4– 4	8	1– 4	2	0– 0	0	0– 0	0	0– 0	0	....
1915	42 15	91	0– 0	0	0– 0	0	1– 4	4	7–14	20	9 14	22	13– 1	26	10–14	19	0– 0	0	0– 0	0	0– 0	0	....
Average	**35.6**	**81**	**0.3**	**1**	**1.6**	**6**	**3.8**	**11**	**8.4**	**21**	**9.2**	**20**	**7.0**	**14**	**3.4**	**6**	**1.3**	**2**	**0.4**	**0.5**	**0**	**0**	....
Standard grade—																							
1912	13– 1	32	0– 4	1	0– 5	1	1– 8	4	2– 1	5	5– 4	11	1–15	7	1–12	3	0– 0	0	0– 0	0	0– 0	0	....
1913	6– 3	23	3– 4	14	2– 2	7	0– 6	1	0– 0	0	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0– 0	0	....

1914	1–15	6	0– 8	2	0–10	2	0– 6	1	0– 0	0	0– 7	1	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0 0 –	0	....
1915	14– 4	33	0– 0	0	0– 8	2	1–10	5	1– 1	3	4–12	11	3– 5	7	1–11	3	0–10	1	0–11	1	0– 0	0	....
Average	**8.9**	**24**	**1.0**	**4**	**0.9**	**3**	**1.0**	**3**	**0.8**	**2**	**2.7**	**6**	**1.3**	**4**	**0.9**	**2**	**0.2**	**0.3**	**0.2**	**0.3**	**0**	**0**	....
Cull fruits—																							
1912	4–15	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	5– 6	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	1– 0	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	4– 1	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	**3.8**	**13**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total crop—																							
1912	57– 0	125	0– 4	1	1– 5	4	3– 6	9	10– 6	25	15– 4	33	11– 5	25	3– 6	6	5– 1	8	1–12	2	0– 0	0	6
1913	30–10	97	4– 3	18	5– 7	19	5–14	17	5– 9	14	2–11	6	1– 8	3	0– 0	0	0– 0	0	0– 0	0	0– 0	0	0
1914	44– 7	113	0–12	3	2–14	9	7– 2	20	12– 0	29	15– 3	33	4– 4	8	1– 4	2	0– 0	0	0– 0	0	0– 0	0	0
1915	61– 4	136	0– 0	0	0– 8	2	2–14	9	8–15	23	14–10	33	16– 6	33	12– 9	22	0–10	1	0–11	1	0– 0	0	0
Average	**48.3**	**118**	**1.3**	**6**	**2.5**	**9**	**4.8**	**14**	**9.2**	**23**	**11.9**	**26**	**8.4**	**17**	**4.3**	**6**	**1.4**	**2**	**0.6**	**0.8**	**0**	**0**	**2**

Table IV includes all the trees listed in Table II, and it is interesting to note the relative position of these trees when they are listed according to their rank for the two periods. Tables VI and VII show these comparisons for some of the highest and some of the lowest producing trees.

TABLE VI.—*Comparative rank of the 19 of the 40 highest producing and of the 17 of the 40 lowest producing Washington Navel orange trees in the 4-year performance record plats on which data were also obtained for the 6-year period.*

[Trees marked with an asterisk (*) are not included in the 6-year record plat.]

Highest producing trees.				Lowest producing trees.			
	Rank for the 4-year period.				Rank for the 4-year period.		
Tree designation.	The 40 highest producing trees.[1]	The 19 trees for which records have been obtained for 6 years.	Rank for the 6-year period.[2]	Tree designation.	The 40 lowest producing trees.	The 17 trees for which records have been obtained for 6 years.	Rank for the 6-year period.
3–14–27	1	1	1	*6:1–55– 5	1		
3–12–28	2	2	2	*10:2– 7–17	2		
*11–52–13	3			7:1–52– 3	3	1	1
*11–52–15	4			*SM–3–32–15	4		
3–13–29	5	3	3	*7:1–53–11	5		
3–13–28	6	4	6	7:1–67–13	6	2	4
*3–23–27	7			7:1–65–23	7	3	2
3–12–29	8	5	5	7:1–66–12	8	4	5
*11–52–14	9			*6:1–71–10	9		
3–12–30	10	6	7	*SM–3–29–16	10		
3–14–26	11	7	4	*SM–3–32–20	11		
*8–16–20	12			7:1–66–10	12	5	3
*7:2–34– 2	13			7:1–68–12	13	6	6
*3–22–27	14			*6:1–71– 7	14		
*11–52–12	15			7:1–68–14	15	7	8
4–27–16	16	8	9	*SM–3–33–15	16		
7:2–37– 1	17	9	11	*6:1–64– 3	17		
7:2–25– 1	18	10	10	7:1–68– 8	18	8	7
10:1–28– 9	19	11	14	*SM–3–33–12	19		
*3–13–25	20			7:1–67– 6	20	9	9
*3–14–23	21			*7:1–51–20	21		
*5–41– 7	22			*10:2– 6–13	22		
10:1–29– 2	23	12	20	7:1–67– 9	23	10	10
*7:2–30– 1	24			*10:2– 8–14	24		
7:2–32– 3	25	13	15	*SM–3–32–17	25		
*5–36– 1	26			7:1–67– 8	26	11	13
10:1–29– 8	27	14	12	*SM–3–25–16	27		
3–14–25	28	15	8	*SM–3–33–14	28		
*5–40– 4	29			*10:2– 6–12	29		
*5–41– 6	30			*SM–3–33–13	30		
10:1–32– 6	31	16	18	*10:2– 8–15	31		
*5–40– 5	32			7:1–67–12	32	12	15
4–23– 3	33	17	19	7:1–68–10	33	13	11
*9– 2– 5	34			*7:1–53–12	34		
*7:2– 8– 1	35			7:1–67– 7	35	14	12
*7:2–17– 2	36			7:1–68– 9	36	15	14
*5–38– 6	37			*SM–3–31–14	37		
*7:1–59–11	38			7:1–68– 6	38	16	17
7.2–25– 3	39	18	21	*SM–3–30–15	39		
10:1–30– 9	40	19	30	7:1–68–13	40	17	16

[1] Ranked as shown in Table IV. [2] Ranked as shown in Table II.

Table VI shows the comparative rank of 19 trees on which records have been secured for six years, which are among the 40 highest producing trees in the 4-year plat. Column 3 in this table shows the 4-year rank in which the trees would be listed if only those were

recorded on which data had also been secured for six years, and column 4 shows the rank secured by the same trees on the basis of their 6-year performance records as shown in Table II. The facts that the same trees appear in the first three ranks in both summaries and that the other trees represented are so nearly identical in their rank for the two periods show that for all practical purposes performance records of full-bearing trees for four years are as satisfactory as those for six years.

This is additional evidence in support of the general proposition that the variation in the amount of the annual crops produced by a given series of individual Washington Navel orange trees is relatively uniform throughout the series each year; that is, the highest producing trees in any one year are in general the highest producing ones each year, and the lowest producing ones remain at the bottom of the list continually. Table VI also offers additional support of the general proposition that individual trees are relatively very stable over a series of years in the character and the amount of their fruit production.

Table VI also shows the relative ranks of the lowest producing trees recorded for both the 4-year and 6-year periods. The individual trees listed here are even more nearly identical in their rank for the two periods than were those in the highest producing ranks, giving additional evidence in support of the truths just stated.

Table VII shows the annual performance record of a tree of the Productive Washington strain for the season of 1914 and also the 6-year period performance record of the same tree. This table is presented for the purpose of comparison with Table VIII, showing the annual and period performance records of a tree of the Unproductive strain, and with Table IX, showing the annual and period performance records of a tree of the Wrinkled Australian strain. These tables illustrate the form in which the data have been recorded during all the investigational work on which this publication is based, except that in order to economize space the form for recording the detailed data for 1914 has been rearranged.

These records show the comparative behavior of typical examples of three Washington Navel orange strains which are of great importance in the study of the origin of varieties by bud selection. The marked variations in the quantity and commercial quality of the fruit borne by these trees illustrate the relative value of these strains and are typical of the differences in production that exist in other strains of this variety.

TABLE VII.—*Performance record of the Washington Navel orange tree No. 3–14–27, Productive Washington strain, showing the weight and number of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1914 and summarized for a period of six seasons, 1910 to 1915, inclusive.*

[The summarized record illustrates the method of assembling the data of successive seasons for careful comparison and study. In practice, the variable fruits produced by the tree each season are listed on the back of the form. The weights are given in pounds and ounces, except that the 6-year totals and the averages are expressed decimally in pounds. This tree is listed in rank 1 in Tables II, III, IV, and V.]

DETAILED RECORD FOR THE SEASON OF 1914.[1]

Sizes of fruits.	Orchard grade.		Standard grade.		Total.		Cull fruits.		Grand total.	
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.
288 and smaller	1–10	8	1– 1	6	2–11	14	.....	.....	.....	.....
250	5– 6	19	0–15	3	6– 5	22	.....	.....	.....	.....
216	19–14	59	2–10	7	22– 8	66	.....	.....	.....	.....
200	51–15	133	2–12	7	54–11	140	.....	.....	.....	.....
176	126–10	277	6–12	16	133– 6	293	.....	.....	.....	.....
150	125–12	238	4– 9	9	130– 5	247	.....	.....	.....	.....
126	99– 6	167	4– 8	8	103–14	175	.....	.....	.....	.....
112	21–14	33	1– 4	2	23– 2	35	.....	.....	.....	.....
96	8– 4	11	0– 0	0	8– 4	11	.....	.....	.....	.....
80 and larger	0–13	1	0– 0	0	0–13	1	.....	.....	.....	.....
Total	461– 8	946	24– 7	58	485–15	1,004	17–4	38	503–3	1,042

SUMMARIZED RECORD FOR SIX SEASONS.

Grades and sizes.	1910	1911	1912	1913	1914	1915	Total.	Average.
Weight of fruits:								
Orchard grade	382– 7	271–14	315– 0	152–14	461– 8	352– 2	1,935.8	322.6
Standard grade	7–10	27–15	23–11	34– 7	24– 7	78–12	196.9	32.8
Culls [2]	0– 0	23–14	16– 3	103–12	17– 4	69–13	230.9	38.5
Grand total	390– 1	323–11	354–14	291– 1	563– 3	500–11	2,363.6	393.9
Sizes—								
288 and smaller	2– 9	0– 4	3– 5	0– 7	2–11	0– 5	9.6	1.6
250	11–12	0– 0	4– 2	1–13	6– 5	1– 2	25.1	4.2
216	15– 8	0–12	7– 0	11– 1	22– 8	7– 1	63.9	10.6
200	48–11	2– 8	32–11	15– 1	54–11	18– 8	172.7	28.8
176	66–10	6– 1	32–11	32– 6	133– 6	41– 7	312.6	52.1
150	98– 0	35– 7	90– 1	47– 6	130– 5	79– 5	480.5	80.1
126	28–14	8– 7	30– 2	45– 1	103–14	139–11	356.1	59.3
112	70–11	62– 2	79–13	15–13	23– 2	73– 3	324.8	54.1
96	28– 7	98–12	41– 0	10– 0	8– 4	46– 3	232.6	38.8
80 and larger	18–15	85– 8	17–14	7–12	0–13	24– 1	154.9	25.8
Total	390– 1	299–13	338–11	187– 5	485–15	430–14	2,132.7	355.4
Number of fruits:								
Orchard grade	738	385	581	310	946	661	3,621	603.5
Standard grade	19	45	57	80	58	151	410	68.3
Culls [2]	0	38	41	311	38	165	593	98.8
Grand total	757	468	679	701	1,042	977	4,624	770.6
Sizes—								
288 and smaller	10	1	14	2	14	2	43	7.2
250	36	0	13	6	22	4	81	13.5
216	41	2	19	34	66	21	183	30.5
200	117	6	80	43	140	49	435	72.5
176	141	13	72	77	293	98	694	115.7
150	189	66	174	98	247	165	939	156.5
126	49	15	54	80	175	252	625	104.2
112	111	98	131	25	35	120	520	86.7
96	40	135	59	15	11	69	329	54.8
80 and larger	23	94	22	10	1	32	182	30.2
Total	757	430	638	390	1,004	812	4,031	671.8

[1] Fine quality fruit; 11½ boxes. Variable fruits: Australian, 1; protruding, 3; ridged, 3; abnormal shape, 1; split navel, 7; split side, 3.

[2] The excessive number of culls occurring in 1913 was largely caused by the severe freeze of that season.

TABLE VIII.—*Performance record of the Washington Navel orange tree No. 7:1–66–12, Unproductive strain, showing the number and weight of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1914 and summarized for a period of six seasons, 1910 to 1915, inclusive.*

[The summarized record illustrates the method of assembling the data of successive seasons for careful comparison and study. In practice the variable fruits produced by the tree each season are listed on the back of the form. The weights are given in pounds and ounces, except that the 6-year totals and the averages are expressed decimally in pounds. This tree is listed in rank 147 in Table II and in rank 474 in Table IV.]

DETAILED RECORD FOR THE SEASON OF 1914.[1]

Sizes of fruits.	Orchard grade.		Standard grade.		Total.		Cull fruits.		Grand total.	
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.
288 and smaller	0–12	3	4– 7	21	5– 3	24	.....	.....	.....	.....
250	0–14	3	0– 0	0	0–14	3	.....	.....	.....	.....
216	5– 0	14	2– 9	7	7– 9	21	.....	.....	.....	.....
200	3– 9	9	0– 0	0	3– 9	9	.....	.....	.....	.....
176	6– 8	14	0–14	2	7– 6	16	.....	.....	.....	.....
150	1– 9	3	0– 0	0	1– 9	3	.....	.....	.....	.....
126	2– 0	3	0– 0	0	2– 0	3	.....	.....	.....	.....
112	0–11	1	0– 0	0	0–11	1	.....	.....	.....	.....
96	0– 0	0	0– 0	0	0– 0	0	.....	.....	.....	.....
80 and larger	0– 0	0	0– 0	0	0– 0	0	.....	.....	.....	.....
Total	20–15	50	7–14	30	28–13	80	2– 2	14	30–15	94

SUMMARIZED RECORD FOR SIX SEASONS.

Grades and sizes.	1910	1911	1912	1913	1914	1915	Total.	Average.
Weight of fruits:								
Orchard grade	60– 7	48– 4	74– 1	46–13	20–15	33– 3	283.7	47.3
Standard grade	12– 7	12–10	13– 1	18–15	7–14	49– 0	113.9	19.0
Culls	0– 0	3– 0	8–11	19– 3	2– 2	4–11	37.7	6.3
Grand total	72–14	63–14	95–13	84–15	30–15	86–14	435.3	72.6
Sizes—								
288 and smaller	2– 7	1–13	31– 2	6–15	5– 3	3– 2	50.6	8.4
250	5– 1	9– 2	27– 1	9– 9	0–14	0– 0	51.7	8.6
216	7– 7	5–14	14– 4	12–12	7– 9	4–10	52.5	8.8
200	13– 6	15–13	11–11	9– 1	3– 9	4– 6	57.9	9.7
176	15–11	10– 8	2– 8	10– 2	7– 6	6–10	52.8	8.8
150	18– 7	11–10	0– 8	9– 4	1– 9	15–10	57.0	9.5
126	3– 7	3– 4	0– 0	7– 6	2– 0	15–13	31.9	5.3
112	4– 6	2–14	0– 0	0– 0	0–11	9–14	17.8	3.0
96	2–10	0– 0	0– 0	0–11	0– 0	8– 5	11.6	1.9
80 and larger	0– 0	0– 0	0– 0	0– 0	0– 0	13–13	13.8	2.3
Total	72–14	60–14	87– 2	65–12	28–13	82– 3	397.6	66.3
Number of fruits:								
Orchard grade	145	116	243	127	50	68	749	124.8
Standard grade	29	30	54	52	30	94	289	48.2
Culls	0	7	53	60	14	15	149	24.8
Grand total	174	153	350	239	94	177	1,187	197.8
Sizes—								
288 and smaller	9	7	132	29	24	16	217	36.2
250	16	28	87	34	3	0	168	28.0
216	22	16	41	37	21	14	151	25.2
200	35	38	30	24	9	12	148	24.7
176	36	23	6	23	16	16	120	20.0
150	39	23	1	18	3	32	116	19.3
126	6	6	0	13	3	28	56	9.3
112	7	5	0	0	1	16	29	4.8
96	4	0	0	1	0	12	17	2.8
80 and larger	0	0	0	0	0	16	16	2.7
Total	174	146	297	179	80	162	1,038	173.0

[1] Total crop, one-half box. Variable fruits: Protruding, 3; split navel, 3.

TABLE IX.—*Performance record of the Washington Navel orange tree No. 7:1–56–5, Wrinkled Australian strain, showing the number and weight of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1914 and summarized for a period of four seasons, 1912 to 1915, inclusive.*

[The summarized record illustrates the method of assembling the data of successive seasons for careful comparison and study. In practice the variable fruits produced by the tree each season are listed on the back of the form. The weights are given in pounds and ounces, except that the 4-year totals and the averages are expressed decimally in pounds. This tree is listed in rank 412 in Tables IV and V.]

DETAILED RECORD FOR THE SEASON OF 1914.[1]

Sizes of fruits.	Orchard grade.		Standard grade.		Total.		Cull fruits.		Grand total.	
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.
288 and smaller	0–12	3	3– 0	16	3–12	19				
250	0–10	2	5– 0	16	5–10	18				
216	1–12	5	19– 2	53	20–14	58				
200	4– 5	12	11– 3	28	15– 8	40				
176	2– 2	5	27– 4	61	29– 6	66				
150	0– 0	0	21– 4	42	21– 4	42				
126	0– 0	0	24–12	27	24–12	27				
112	0– 0	0	3– 0	5	3– 0	5				
96	0– 0	0	0–11	1	0–11	1				
80 and larger	0– 0	0	0– 0	0	0– 0	0				
Total	9– 9	27	115– 4	249	124–13	276	5–15	29	130–12	305

SUMMARIZED RECORD FOR FOUR SEASONS.

Grades and sizes.	1912	1913	1914	1915	Total.	Average.
Weight of fruits:						
Orchard grade	89– 3	41– 2	9– 9	8– 6	148.2	37. 1
Standard grade	58– 0	78– 0	115– 4	59–15	311.2	77. 8
Culls	11– 5	23– 2	5–15	4– 2	44.5	11. 1
Grand total	158– 8	142– 4	130–12	72– 7	503.9	126. 0
Sizes—						
288 and smaller	13– 5	37– 6	3–12	1– 4	55.7	13. 9
250	25–12	26– 4	5–10	1–12	59.4	14. 9
216	26–15	28–14	20–14	6–10	83.3	20. 8
200	40– 1	14–15	15– 8	10– 8	81.0	20. 3
176	24–15	7– 0	29– 6	14– 2	75.4	18. 9
150	13–14	4– 3	21– 4	22– 3	61.5	15. 4
126	1–11	0– 8	24–12	7– 9	34.5	8. 6
112	0–10	0– 0	3– 0	1–11	5.3	1. 3
96	0– 0	0– 0	0–11	2–10	3.3	0. 8
80 and larger	0– 0	0– 0	0– 0	0– 0	0.0	0
Total	147– 3	119– 2	124–13	68– 5	459.4	114. 9
Number of fruits:						
Orchard grade	237	126	27	18	408	102. 0
Standard grade	196	310	249	145	900	225. 0
Culls	46	96	29	12	183	45. 8
Grand total	479	532	305	175	1,491	372. 8
Sizes—						
288 and smaller	92	181	19	6	298	74. 5
250	78	100	18	6	202	50. 5
216	74	88	58	20	240	60. 0
200	101	40	40	28	209	52.25
176	56	17	66	35	174	43. 5
150	28	9	42	47	126	31. 5
126	3	1	27	14	45	11.25
112	1	0	5	3	9	2.25
96	0	0	1	4	5	1.25
80 and larger	0	0	0	0	0	0
Total	433	436	276	163	1,308	327. 0

[1] Total crop, 2¼ boxes. Variable fruits: Wrinkled, 256; split side, 1,

TABLE X.—*Performance record of the Washington Navel orange tree No. 11–52–13, Productive Washington strain, showing the number and weight of the fruits of each grade and size produced, summarized for a period of five seasons, 1911 to 1915, inclusive.*

[This table shows a steady increase in production. The weights are given in pounds and ounces, except that the 5-year totals and the averages are expressed decimally in pounds. This tree is listed in rank 3 in Tables IV and V.]

Grades and sizes.	1911	1912	1913	1914	1915	Total.	Average.
Weight of fruits:							
Orchard grade	267–5	334–12	250–0	392–15	390–4	1,635.3	327.1
Standard grade	12–11	31–7	72–7	13–1	92–0	221.6	44.3
Culls[1]	5–2	10–6	24–4	3–12	11–8	55.0	11.0
Total	285–2	376–9	346–11	409–12	493–12	1,911.9	382.4
Sizes—							
288 and smaller	0–6	5–9	13–10	13–12	6–8	39.8	7.96
250	0–15	14–10	32–1	21–12	2–8	71.9	14.38
216	1–8	20–9	61–14	79–10	8–8	172.1	34.42
200	6–12	66–12	62–6	92–3	17–11	245.8	49.16
176	13–12	67–0	75–7	118–1	65–10	339.9	67.98
150	43–14	104–8	50–11	58–2	109–9	366.7	73.34
126	10–0	17–11	23–2	16–2	157–15	224.9	44.98
112	56–9	53–13	3–4	3–6	61–13	178.8	35.76
96	88–6	15–11	0–0	2–4	34–10	140.9	28.18
80 and larger	57–14	0–0	0–0	0–12	17–8	76.1	15.22
Total	280–0	366–3	322–7	406–0	482–4	1,856.9	371.38
Number of fruits:							
Orchard grade	416	726	629	942	782	3,495	699
Standard grade	25	77	204	54	206	566	113
Culls[1]	26	30	79	13	38	186	37
Total	467	833	912	1,009	1,026	4,247	849
Sizes—							
288 and smaller	2	22	58	73	35	190	38
250	3	45	111	73	9	241	48
216	4	58	181	198	26	467	93
200	16	169	160	235	48	628	126
176	30	148	173	264	155	770	154
150	83	210	103	116	233	745	149
126	18	33	42	28	299	420	84
112	91	94	5	5	105	300	60
96	125	24	0	3	54	206	41
80 and larger	69	0	0	1	24	94	19
Total	441	803	833	996	988	4,061	812

[1] The large number of culls occurring in 1913 were caused by the severe freeze of that season.

The seasonal variation in production within a strain is illustrated in Tables X, XI, and XII. Table X shows the period performance record for five seasons of the tree of the Productive Washington strain which is listed in rank 3 in Tables IV and V. This record shows a regular increase in production from year to year, a condition which is most desirable from the standpoint of profitable orange growing. Table XI shows the period performance record for five seasons of the tree of the Productive Washington strain which is listed in rank 262 in Tables IV and V. This record is comparable with that in Table X, but shows a gradual decrease in production, a condition which is undesirable. Table XII shows the period performance record of the tree of the Productive Washington strain which is listed in rank 50 in Table II and in rank 87 in Table IV. This record illustrates the alternate-bearing habit of many of the trees under observation. A heavy crop is followed by a lighter one the next season, but the production gradually increases during a period of several

years. The freeze of 1913 reduced the yield of that season below normal, which explains the apparent exception to this rule shown in the production of that year in this table. The trees having a habit of regular production are more desirable than those having a habit of alternate production, but the alternate-bearing trees may not be unprofitable to the grower. In propagation work, buds should be selected only from trees which show a regular and increasing production. The desirability of top-working alternate-bearing trees will depend upon the profitableness of their yield during several seasons, preferably for an even number of years. The trees showing a regular decrease in yield should be top-worked when their production is no longer profitable, using buds from trees producing heavy and regular crops.

Table XIII shows the variation in average yields for a 4-year performance-record period of all the trees under observation, arranged in groups illustrating the comparative behavior of different strains and of select trees within some of these strains.

TABLE XI.—*Performance record of the Washington Navel orange tree No. 7:1–51–16, Productive Washington strain, showing the number and weight of the fruits of each grade and size produced, summarized for a period of five seasons, 1911 to 1915, inclusive.*

[This table plainly shows a gradual decrease in production. The weights are given in pounds and ounces, except that the 5-year totals and the averages are expressed decimally in pounds. This tree is listed in rank 262 in Tables IV and V.]

Grades and sizes.	1911	1912	1913	1914	1915	Total.	Average.
Weight of fruits:							
Orchard grade	276–15	258– 8	128– 5	149– 7	106– 6	919.6	183.92
Standard grade	21–10	14–13	22– 3	20– 7	7–11	86.7	17.34
Culls[1]	2– 0	18– 4	35– 0	7– 2	8– 8	70.9	14.18
Total	300– 9	291– 9	185– 8	177– 0	122– 9	1,077.2	215.44
Sizes—							
288 and smaller	1– 6	27– 0	24– 7	7–14	2– 0	62.7	12.54
250	7– 2	43– 7	32– 2	20– 3	2– 2	105.0	21.00
216	11– 0	40– 6	39– 5	35– 1	12– 8	138.3	27.66
200	37– 0	76–14	23– 7	40– 7	17– 4	195.0	39.00
176	39–10	42–15	21–15	55– 1	27–11	187.3	37.46
150	101– 0	32– 4	6– 6	6– 1	24– 9	170.2	34.04
126	14–11	5– 5	2– 5	5– 3	19– 0	46.5	9.30
112	57– 5	5– 2	0– 9	0– 0	5–10	68.6	13.72
96	20–15	0– 0	0– 0	0– 0	3– 5	24.2	4.84
80 and larger	8– 8	0– 0	0– 0	0– 0	0– 0	8.5	1.70
Total	298– 9	273– 5	150– 8	169–14	114– 1	1,006.3	201.26
Number of fruits:							
Orchard grade	519	696	389	376	240	2,220	444
Standard grade	48	54	84	66	24	276	55
Culls[1]	4	73	150	34	29	290	58
Total	571	823	623	476	293	2,786	557
Sizes—							
288 and smaller	6	108	107	35	10	266	53.2
250	22	140	114	66	7	349	69.8
216	29	117	121	98	37	402	80.4
200	88	200	62	100	46	496	99.2
176	84	99	51	122	65	421	84.2
150	180	67	13	12	51	323	64.6
126	25	10	4	9	34	82	16.4
112	92	9	1	0	9	111	22.2
96	30	0	0	0	5	35	7.0
80 and larger	11	0	0	0	0	11	2.2
Total	567	750	473	442	264	2,496	499.2

[1] The large number of culls occurring in 1913 were caused by the severe freeze of that season.

TABLE XII.—*Performance record of the Washington Navel orange tree No. 4–23–2, Productive Washington strain, showing the number and weight of the fruits of each grade and size produced, summarized for a period of six seasons, 1910 to 1915, inclusive.*

[This table plainly shows the tendency of this tree to bear heavier crops in alternate seasons. The weights are given in pounds and ounces, except that the 6-year totals and the averages are expressed decimally in pounds. This tree is listed in rank 50 in Table II and in rank 87 in Table IV.]

Grades and sizes.	1910	1911	1912	1913	1914	1915	Total.	Average.
Weight of fruits:								
Orchard grade	246– 0	138– 4	242– 3	66– 7	319–10	192– 0	1,204.5	200.75
Standard grade	8– 1	21– 8	14– 3	40– 9	33– 2	30– 3	147.6	24.60
Culls[1]	0– 0	9– 4	4– 6	54–14	4– 4	11– 0	83.8	13.97
Total	254– 1	169– 0	260–12	161–14	357– 0	233– 3	1,435.9	239.32
Sizes—								
288 and smaller	1–14	0– 4	3– 6	6– 3	2– 3	0– 3	14.1	2.35
250	7–14	0– 5	8– 4	9– 0	4– 9	1– 2	31.1	5.18
216	12–10	0– 6	8– 6	19– 0	16–10	1–10	58.6	9.76
200	33– 4	4–14	33– 5	14– 4	26–13	6– 3	118.7	19.78
176	45– 9	10–10	39– 8	18–10	82–15	24– 9	221.8	36.97
150	64–14	22– 4	65–11	19– 3	90– 1	51–14	313.9	52.32
126	24– 3	6– 2	15– 3	15– 2	87–15	71–11	220.3	36.72
112	34– 2	43– 5	51–12	2–12	23– 2	24– 7	179.5	29.92
96	29–11	44– 0	22–14	2– 1	15– 2	20–11	134.4	22.40
80 and larger	0– 0	27–10	8– 1	0–13	3– 6	19–13	59.7	9.95
Total	254– 1	159–12	256– 6	107– 0	352–12	222– 3	1,352.1	225.35
Number of fruits:								
Orchard grade	484	205	476	167	614	332	2,278	380
Standard grade	19	35	35	117	70	56	332	55
Culls[1]	0	30	12	179	11	29	261	44
Total	503	270	523	463	695	417	2,871	479
Sizes—								
288 and smaller	12	1	14	27	10	1	65	11
250	25	1	25	33	16	4	104	17
216	35	1	23	60	47	5	171	29
200	79	11	81	39	67	15	292	49
176	96	22	85	46	177	54	480	80
150	120	40	127	42	167	100	596	99
126	41	10	27	28	142	119	367	61
112	56	67	85	5	34	37	284	47
96	39	58	34	3	20	29	183	31
80 and larger	0	29	10	1	4	24	68	11
Total	503	240	511	284	684	388	2,610	435

[1] The large number of culls in 1913 were caused by the severe freeze of that season.

TABLE XIII.—*Average annual crop of individual Washington Navel orange trees of several of the important strains found in the investigational performance-record plats, ranked according to the weight of their average total crops and showing production, by commercial grades, for four years, 1912 to 1915, inclusive.*

Number of trees.	Description of trees.	Average annual production per tree (pounds).			
		Total crop.	Orchard grade.	Standard grade.	Cull fruits.
10	Highest producing (all Washington strain)	373.3	293.8	49.8	29.7
4	Thomson-Washington strain	267.2	224.4	32.3	10.5
1	Yellow Thomson strain	264.3	173.9	47.6	42.8
2	Sporting Thomson strain	231.4	163.7	42.0	25.7
51	Thomson strain	226.8	185.3	31.0	10.5
363	Washington strain	207.4	163.4	27.6	16.4
8	Golden Nugget strain	199.5	127.7	32.1	39.7
1	Washington-Thomson strain	150.4	128.8	15.1	6.5
2	Wrinkled Australian strain	144.1	42.4	85.4	16.3
1	Sporting Washington strain	140.0	51.5	72.3	16.2
13	Yellow Washington strain	114.7	85.8	15.6	13.3
10	Lowest producing, Washington strain	106.5	80.7	18.7	7.1
35	Unproductive strain	83.2	59.4	16.2	7.6
10	Lowest producing (irrespective of strain)	63.0	42.8	13.0	7.2
	General average	198.0	155.2	27.4	15.4

The groups do not include equal numbers of trees, so no attempt should be made to draw final conclusions from Table XIII as to the exact behavior of the different strains represented. Although the average of the crops of the 51 trees of the Thomson strain is higher than the average of the 363 trees of the Washington strain, the heaviest producing individual trees are of the Washington strain. If the average of the Washington strain can be raised by bud selection to the average of the best trees within this strain as indicated by these investigations, then the strain as a whole will be more productive than the Thomson strain. The superior quality of the fruit of the Washington strain, as mentioned in the description of that strain, is an added reason for its propagation.

Table XIV shows the same groups of trees as those in Table XIII, but arranged in the order of their average individual tree production of first-grade fruit. On this basis of rank, the 10 highest producing trees of the Washington strain retain their position in first place. Table XIV, together with Table XIII, brings out the fact established in these investigations that the heaviest yielding trees also produce the largest quantity of first-grade fruit, and the lowest yielding trees produce the smallest quantity of fruit of this grade.

TABLE XIV.—*Average annual crop of individual Washington Navel orange trees of several of the important strains found in the investigational performance-record plats, ranked according to the weight of the fruits of the Orchard grade produced and showing production, by commercial grades for four years, 1912 to 1915, inclusive.*

Number of trees.	Description of trees.	Average annual production per tree (pounds).			
		Orchard grade.	Standard grade.	Cull fruits.	Total crop.
10	Highest producing (all Washington strain)	293.8	49.8	29.7	373.3
4	Thomson-Washington strain	224.4	32.3	10.5	267.2
51	Thomson strain	185.3	31.0	10.5	226.8
1	Yellow Thomson strain	173.9	47.6	42.8	264.3
2	Sporting Thomson strain	163.7	42.0	25.7	231.4
363	Washington strain	163.4	27.6	16.4	207.4
1	Washington-Thomson strain	128.8	15.1	6.5	150.4
8	Golden Nugget strain	127.7	32.1	39.7	199.5
13	Yellow Washington strain	85.8	15.6	13.3	114.7
10	Lowest producing, Washington strain	80.7	18.7	7.1	106.5
35	Unproductive strain	59.4	16.2	7.6	83.2
1	Sporting Washington strain	51.5	72.3	16.2	140.0
10	Lowest producing (irrespective of strain)	42.8	13.0	7.2	63.0
2	Wrinkled Australian strain	42.4	85.4	16.3	144.1
	General average	155.2	27.4	15.4	198.0

Figure 9, which is prepared from the data presented in Table XIV, shows graphically the percentages of fruits of the Orchard, Standard, and Cull grades in the average annual crops of individual trees of some of the Washington Navel orange strains, ranked in the order of their production by weight of first-grade fruit. The commercial grades are assorted on the basis of appearance, including the shape

of the fruit, color and texture of the rind, and its freedom from scars, blemishes, or abnormal markings. By reason of the higher color and smoother texture of the rind of the Thomson fruits there usually is a larger proportion of first-grade fruit produced by this strain than by

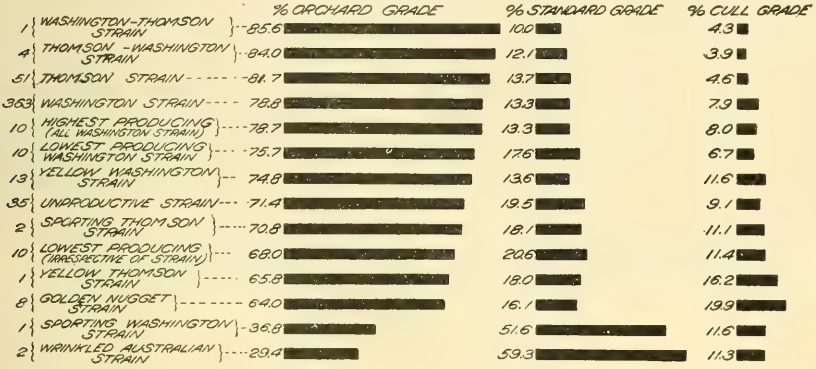


FIG. 9.—Diagram showing the percentages of fruit of the different commercial grades produced by the trees of the several strains of the Washington Navel orange in the investigational performance-record plats during a 4-year period, 1912 to 1915, inclusive. The strains are listed according to their proportion by weight of Orchard (or first) grade fruit.

the Washington, as is shown by the relative position of these two in this table. However, the quality of the Thomson fruits, as shown by the texture of the rag and the flavor of the juice, is inferior to that of the Washington fruits. It should be noted that in this diagram

FIG. 10.—Diagram showing the percentages of Orchard and Standard grade fruit in the marketable crops of the trees of the several important strains of the Washington Navel orange found in the investigational performance-record plats during a 4-year period, 1912 to 1915, inclusive. The strains are listed according to their proportion by weight of Orchard (or first) grade fruit.

the two strains ranking highest are ones which have characteristics of both the Washington and Thomson strains. The first one, the Washington-Thomson, bears fruits having the appearance of those of the Washington strain, though the characteristics of flesh and

juice are very similar to those of the Thomson. The second in rank, the Thomson-Washington, bears fruits having the external appearance of the Thomson and the flesh and juice characteristics of the Washington strain. In order to interpret this diagram properly, it should be compared with Table XIV, which shows the actual average crops of the individual trees of these strains.

Figure 10 shows graphically the percentages of fruits of the Orchard and Standard grades in the marketable crops from trees of the various strains found in the investigational performance-record plats for the 4-year period. This diagram emphasizes the production of fruit of the Orchard grade. The commercial fruit grower

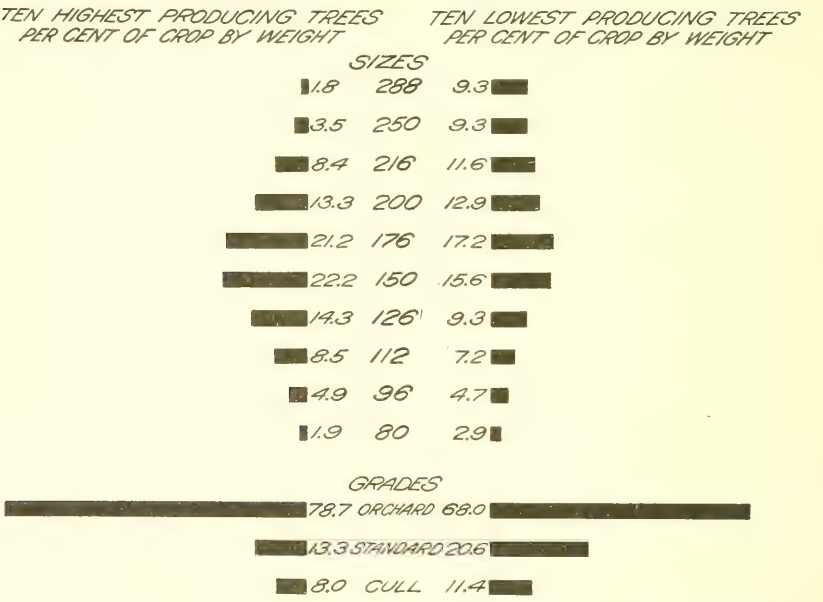


FIG. 11.—Diagram showing the production by commercial sizes and grades of the crops of the 10 highest and 10 lowest producing trees, irrespective of strain, in the investigational performance-record plats of the Washington Navel orange. The figures indicate the proportion of each size or grade to the total crop, calculated from the average weights during a 4-year period, 1912 to 1915, inclusive. Figure 12 shows similar comparisons based on the number of fruits produced.

makes no record of the quantity of cull fruit produced by his trees and hence the percentages given in this figure show the relative quantity of the commercial grades borne by the various strains more accurately than those in figure 9.

Figure 10, like figure 9, is based on the records given in Table XIV and should be interpreted on the basis of those data.

Figure 11 shows the production by commercial sizes and grades of the 10 highest producing trees in the performance-record plats in comparison with the corresponding yields of the 10 lowest producing trees in these plats. The percentages shown are calculated from the

weights of the fruits of the different groups. This diagram shows graphically the fact that the heaviest bearing trees produce the largest proportion of the most desirable and valuable sizes of fruits, namely, 200, 176, 150, and 126 fruits per box. The most productive trees also bear the largest proportion of the Orchard grade, or first-grade, fruits, as shown by this diagram. On the other hand, the lowest producing trees bear a much larger proportion of extremely small and extremely large fruits, both of which are usually undesirable from the market standpoint. Further, the lowest producing trees bear a smaller percentage of the first-grade and a larger percentage of second-grade and cull fruits than the highest producing trees.

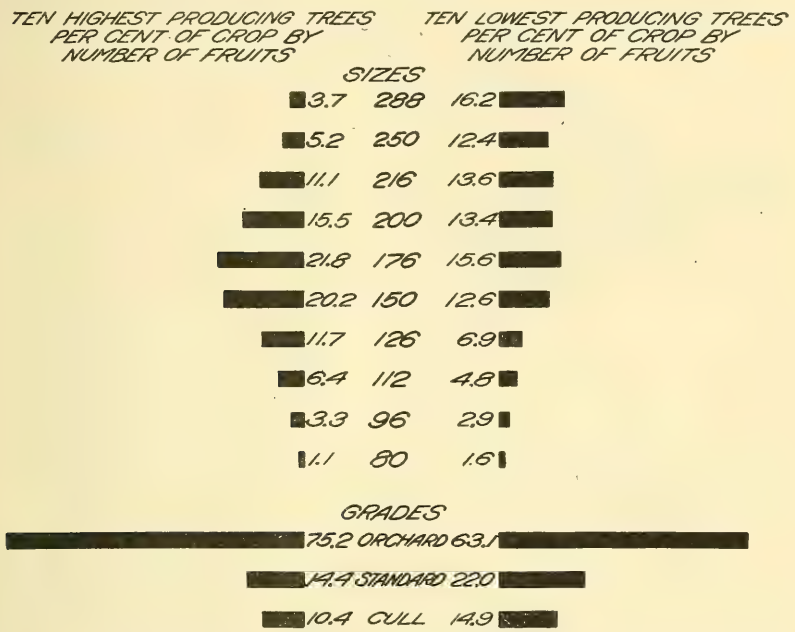


FIG. 12.—Diagram showing the production by commercial sizes and grades of the crops of the 10 highest and 10 lowest producing trees, irrespective of strain, in the investigational performance-record plats of the Washington Navel orange. The figures indicate the proportion of each size or grade to the total crop, calculated from the number of fruits produced during a 4-year period, 1912 to 1915, inclusive. Figure 11 shows similar comparisons based on the weight of the crop.

Figure 12 shows the same comparisons as figure 11, but in this case the percentages are based upon the number of fruits instead of their weights. This diagram brings out even more forcibly than does figure 11 the fact that the heaviest producing trees bear the largest proportion of the most desirable sizes and best grade of fruits.

This correlation of heavy yield and superior commercial grade in the production of Washington Navel orange trees of the Washington strain is very important from the standpoint of the standardization of the variety through bud selection based on performance records.

For this reason the propagation of the highest yielding trees means both larger and better crops of fruit.

In order to present more clearly the importance of the production of the more desirable commercial sizes of fruits by the heavy-yielding trees, figure 13 shows graphically, in terms of packed boxes, the proportions of the various sizes produced by the 10 highest and the 10 lowest yielding trees. This diagram emphasizes the large proportion of the most valuable commercial sizes (200, 176, 150, and 126) borne by the heavy-producing trees in comparison with the small number of fruits of these sizes borne by the low-yielding trees

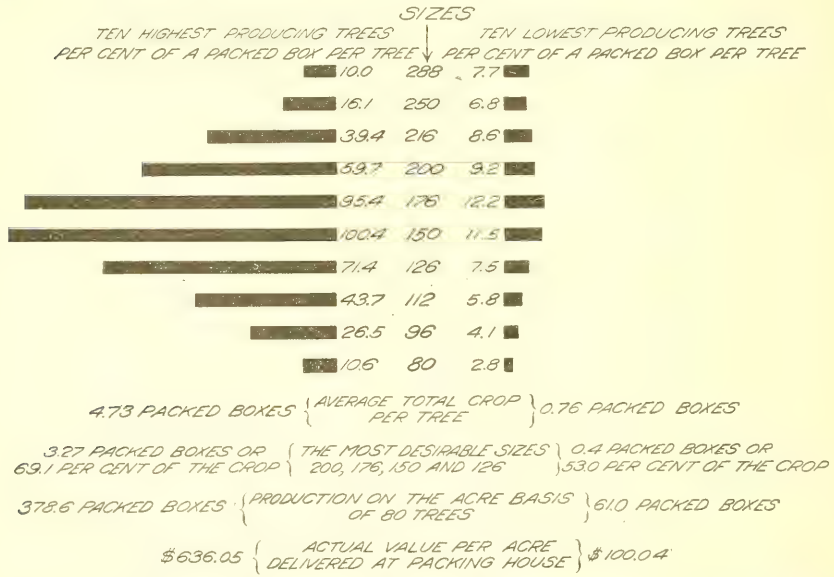


FIG. 13.—Diagram showing the average number of fruits of the various commercial sizes produced annually during a 4-year period by the 10 highest and 10 lowest yielding trees, irrespective of strain, in the investigational performance-record plats of the Washington Navel orange. This production is expressed as percentages of a packed box, calculated from the number of fruits of the different sizes. The percentage of most desirable sizes is also stated, and the production and value are calculated on the acre basis.

The highest producing trees bore an average of 4.73 packed boxes per tree, as compared with a yield of 0.76 of a packed box by the lowest producing trees. On an acre basis at the rate of planting in the performance-record plat, this yield amounted to 378.6 packed boxes per acre for the best trees, as compared with 61 packed boxes per acre for the lowest producing trees. The value of this production, figured on the basis of the actual prices obtained for the crops during the period of observation, was $636.05 per acre annually for the high-producing trees, as compared with $100.04 for the low-producing trees. The higher value of the crops from the high-producing trees is partially due to the fact that 69.1 per cent of their crops was of the most desirable sizes and 78.7 per cent was first-grade

fruit, as compared with only 53 per cent of the most desirable sizes and 68 per cent of first-grade fruit produced by the low-yielding trees.

The production of variable fruits by trees of some of the important strains is shown graphically in figure 14. The low production of these inferior fruits by trees of the Washington strain, amounting to 0.66 per cent, as compared with the large production of such fruits borne by the Thomson, Golden Nugget, Sporting Thomson, Sporting Washington, and Wrinkled Australian strains, shows the superior quality of the Washington strain in this respect. The comparative freedom from variable fruits of many trees of the Washington strain and other characteristics of these trees indicate the possibility of controlling the amount of bud variability in commercial orchards by bud selection based on performance records. In counting the vari-

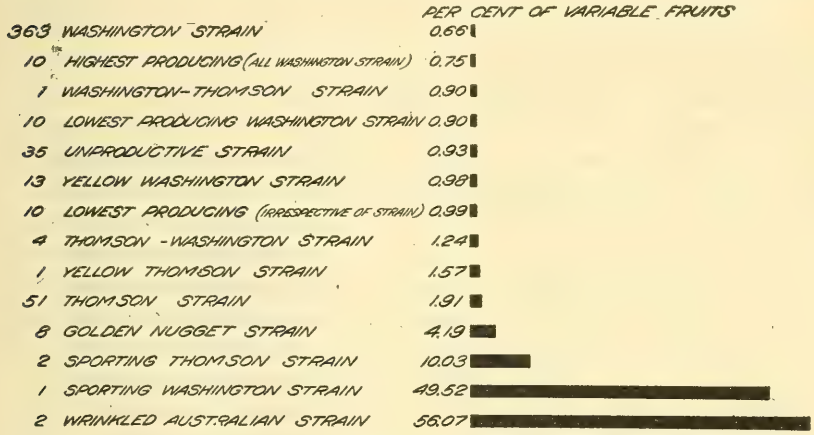


FIG. 14.—Diagram showing the average percentage of variable fruits found on the trees of the different strains of the Washington Navel orange in the investigational performance-record plats during a 4-year period, 1912 to 1915, inclusive. The proportions are based on the total number of fruits produced.

able fruits on a tree, only those showing some marked variation from the general type of the fruits produced by that tree have been recorded; for instance, in the case of trees of the Yellow strain, only those fruits showing some marked variation from the Yellow strain have been listed as variable fruits. On the Sporting Washington and Thomson trees all fruits other than those typical of the Washington or Thomson strains have been listed as variable fruits. In trees of the Wrinkled Australian strain the fruits do not all show the characteristic coarse or wrinkled appearance, so that on these trees all fruits other than those of the Washington strain have been counted as variable fruits.

In figure 15 is shown the average weight per fruit of the total commercial crops of all the trees of the different strains in the performance-record plats. Aside from the factor of size, the amount of juice and

the thickness of the rind are of importance in determining the weight of the individual fruits. This condition is illustrated by the low average weight of the Australian fruits in this diagram. These fruits usually have very thick rinds and a comparatively small quantity of juice. Therefore, although they are usually as large as the fruits of the other strains, they are lighter in weight and inferior in quality.

Other less important contrasting characteristics of the various strains of the Washington Navel orange have been studied in the course of these investigations. All of these studies have added further evidence of the importance of these strains in their relation to commercial orange growing. All the data show that it is very important to isolate the strains of this variety and, for commercial purposes, to propagate only the best of them.

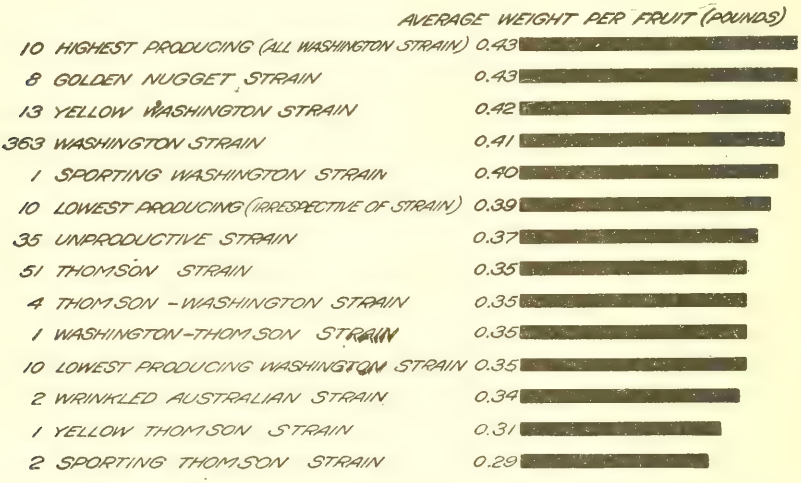


FIG. 15.—Diagram showing the average weight per fruit for the total commercial crops of the trees of the various strains of the Washington Navel orange found in the investigational performance-record plats. These weights are expressed as decimal parts of a pound and are based on data for a 4-year period, 1912 to 1915, inclusive.

COMPARATIVE VALUE OF THE STRAINS.

Any statement as to the comparative value of the various strains of the Washington Navel orange must be understood as applying only to present conditions. What the future of these strains may be under different cultural and market conditions no one can foretell.

Under existing conditions, 2 of the 14 strains are valuable and 3 others are of possible value to orange growers, while 9 are of little or no commercial value. In some cases the inferior strains are not only unproductive, but the poor fruits produced by them are actually detrimental to the general crop of the grove in which they occur, in that it is expensive and sometimes practically impossible to eliminate them during the packing process, and if some are left in the regular

pack the crop in which they are found is likely to be discounted in value when marketed.

The Washington strain, so far as production and the commercial quality of the fruits are concerned, is superior to any other known navel-orange strain. The Thomson, as a rule, produces fruits having a smoother texture and better color of rind than the Washington. This improved appearance results in a higher price per box for Thomson than that paid for similar boxes of Washington fruits in some markets. It is generally conceded that Washington strain oranges are of higher quality than those of the Thomson strain. However, the very smooth texture and deep reddish orange color of the Thomson fruits outweigh other considerations in certain markets. In other important markets the Washington fruits command the highest prices, on account of their superior flavor and the texture of their flesh.

A combination of the valuable characteristics of both the Washington and Thomson strains is desired. As mentioned previously, this condition has been found to exist in the fruits produced by trees of the Thomson-Washington strain. This strain is therefore deserving of a thorough test by orange growers.

The Golden Nugget, Yellow Thomson, and Yellow Washington strains possess some characteristics of value, and their fruits are in some respects, under favorable conditions, considered to be of good quality. Small commercial orchards of these strains have been planted by a few citrus growers in California, and the results of these tests will do much toward deciding their ultimate commercial value.

The remaining strains are more or less undesirable and unprofitable in every respect. The causes for this condition are apparent from their descriptions and their comparative performance records, or from both. Inasmuch as commercial orange orcharding is conducted by the growers in order to make a profit on their investment and labor, the propagation of these inferior strains or their continued culture in established plantings should be discouraged.

As a whole, these investigations have shown that the Washington is the most valuable of all the strains, with the Thomson of secondary commercial importance for special conditions of soil, climate, and market, while the others are of little or doubtful commercial value.

THE UNINTENTIONAL PROPAGATION OF UNDESIRABLE STRAINS.

The prevailing methods of securing bud wood of the Washington Navel orange variety have been to cut this wood either from bearing trees in established orchards or, to a limited extent, from young nursery or nonbearing trees. Where the buds have been cut from bearing trees, little or, usually, no selection of parent trees has been practiced. Suckers, or unusually vigorous nonbearing branches,

have been used almost universally for this purpose. This practice has led to the propagation of a continually increasing proportion of trees of those strains producing the largest amount of sucker growth. Inasmuch as such trees are usually light bearers and produce inferior fruits, this practice has been unfortunate and is the direct cause of the presence of the large proportion of unproductive trees found in many orchards. In cases where fruit wood has been used for propagation, such bud wood has been cut without any fruits attached, so that in many instances buds from sporting limbs have been used, resulting in the development of diverse strains of trees, as shown by the presence of such trees in the established orchards.

The well-known condition of frequent mixture of varieties in deciduous orchards, resulting from the use of bud wood cut from young nursery trees, where buds from different varieties are likely to be mixed or misplaced during propagation, caused the California citrus nurserymen largely to avoid this practice. For this reason only a limited amount of nursery growth has been used for propagation, and consequently but little mixture of varieties has been found in Washington Navel orange orchards.

The presence in established orchards of trees of diverse strains is the direct result of propagating either from individual trees of these strains or from limb variations in trees of the Washington strain. Because this condition of bud variation and strain diversity was practically unknown until established through these investigations, the nurserymen who used bud wood accidentally cut from the sporting branches of trees of the Washington strain (see figs. 7 and 8) or even bud wood from trees of inferior strains are not to blame for the propagation of these diverse and frequently undesirable strains. However, now that the condition of bud variability in the trees of this variety has been established beyond question, any propagator who does not utilize this information and practice the improved methods for securing bud wood from select trees of the best strains will not be able to excuse the poor results of his propagations on the ground of the lack of definite information on this subject.

THE ISOLATION OF STRAINS THROUGH BUD SELECTION.

Fruit-bearing bud wood has been selected from limb variations occurring in trees of the Washington or other strains, and in several hundred cases where the growth from these buds has fruited every selection has come true. In the beginning of this work, the conspicuous bud variations were top-worked in bearing trees in order to get them in fruiting quickly. Later, as opportunity has permitted, the bud variations have been propagated on nursery stocks. Naturally, the results of these progeny tests require considerable time in order to secure reliable performance-record data. In so

far as such trees have fruited, the results have confirmed in every respect those secured by top-working bearing trees. Enough evidence has been secured in these investigations to warrant the statement that in all probability all the strains of the Washington Navel orange can be isolated through bud selection. The isolation of the strains described in this bulletin can be effected either through the selection of bud wood from typical trees in established orchards or from limb variations occurring in bearing trees of the Washington or other strains. In all cases only fruit-bearing bud wood should be used, and one or more typical fruits of the strain desired should be cut off with each bud stick as an indication or label of the characteristics of the bud wood. Figure 16 shows a bud stick of fruit-bearing wood with a typical fruit of the Washington strain attached. The fruits on the bud stick are an indication of the inherent characteristic of the buds from such bud wood and show the probable character of fruit that will be produced by those buds.

FIG. 16.—An orange bud stick of fruit-bearing wood with a Washington strain fruit attached.

The small size of the fruit-bearing bud wood, particularly that growth immediately back of the orange, in comparison with sucker wood growth, has been urged as an objection to its use, particularly if it is necessary to hold the bud wood in storage for some time. These investigations have proved that under proper conditions of storage, viz, sterilized and properly moistened moss and a cool temperature, fruit-bearing bud wood keeps its vitality as well as any other kind of wood. Experience has shown that the use of small bud sticks is as successful in securing a stand of living buds and is as practicable as the use of the larger ones.

The discovery of the practicability and desirability of the use of fruit-bearing bud wood for propagation purposes came about through a study of methods for isolating the navel-orange strains. Experiments with fruit-bearing bud wood proved that the buds from such wood grew equally well and in most cases better than the buds cut from nonfruit-bearing wood. The growth of the young trees from buds taken from fruit-bearing wood has been equally good in all cases and better in most instances than that of trees propagated from sucker or nonfruit-bearing wood.

The isolation of the valuable strains through bud selection is of vital commercial importance to the entire Washington Navel orange industry. The isolation of the inferior strains is of interest only from the experimental standpoint. The propagation of trees of the valuable strains will result not only in increased production but, what is equally important, in a uniform, improved production of improved crops of fruit of greater commercial value. From this standpoint, the isolation of the best strains is of importance, not only to the grower but to the consumer as well.

TOP-WORKING UNDESIRABLE TREES.

The elimination from established orchards of trees of undesirable strains has been effected by top-working these trees with select buds from trees of the Washington strain.

The selection of trees to be top-worked was made before the fruits borne by these trees were picked. While trees of some of the inferior strains can be recognized from their habit of growth or other vegetative characteristics, it is desirable wherever possible to base the final selection on performance records and the characteristics of the fruits.

The selection of bud wood for top-working purposes was based on individual-tree performance records, associated with an intimate knowledge of tree characteristics secured from careful observations of the trees. Only fruit-bearing wood was used, and for the most part only that growth immediately back of the oranges.

In the trees to be top-worked two or three of the main limbs were selected for budding and two buds were inserted in each limb, one on each side, from 12 to 24 inches above the fork of the trunk. After the buds united with the limbs the wraps were removed, the limbs cut off about 6 inches above the buds, and the freshly cut surfaces covered with grafting wax. The trunks and the remainder of the limbs were covered with a heavy coating of whitewash immediately after the tops were removed, in order to prevent injuries from exposure. The sprouts from the limbs and trunk were removed from time to time, in order that the new tops should be made up of the growth from the inserted buds alone. As the buds developed, their growth was controlled by pruning, so as to form a well-branched top capable of bearing full crops of fruit.

After a year's growth, the stubs of the original limbs were cut off just above the bud union, making the cuts oblique in order to facilitate their healing. All cut surfaces were coated with grafting wax or some other suitable covering, in order to prevent decay and to promote the healing processes. Careful attention should be given these trees for the first year or two, to protect the new growth and to guard against undesirable conditions. Afterwards these trees require

no other attention or care than that given the other trees in the orchard.

As a result of these investigations, more than 40,000 undesirable citrus trees in California orchards have been top-worked with buds selected from the most desirable trees in the investigational performance-record plats. The oldest tops grown from these buds are now more than 5 years of age. So far, not a single failure has been observed in transmitting the characteristics of the parent trees by means of the selected buds. The large amount of positive evidence as to the possibility of improving undesirable trees by top-working them with selected buds has resulted in the almost universal adoption of this practice by California citrus growers.

SUMMARY.

The Washington Navel orange is the most important and most extensively grown citrus variety in California.

It was introduced into the United States from Bahia, Brazil, in 1870, by the United States Department of Agriculture. Two trees propagated from this introduction were sent to Mrs. L. C. Tibbets, at Riverside, Cal., in 1873. From this beginning the Washington Navel orange industry has been developed, for the most part within the past 25 years.

There are great variations in the trees and fruit of this variety in California. At least 13 strains possessing very distinct characteristics have been discovered up to the present time.

The objects of these investigations are to determine the comparative behavior of the different strains of the Washington Navel orange variety, to originate and demonstrate methods for their isolation and propagation, to eliminate undesirable trees in established orchards, and to conserve, standardize, and stabilize the variety through bud selection based on individual-tree performance records.

The plan of the investigations is to secure reliable information regarding individual-tree behavior and fruit characteristics by means of systematic performance records.

Individual-tree performance records include a history of the tree, a record of its production, and a description of its fruits and habits of growth.

Bud variations are of frequent occurrence and of great commercial importance in this variety.

Individual fruit variations, such as chimeralike developments and other interesting similar phenomena, are found frequently. Many minor fruit variations have been discovered, and their relation to more important variations is being investigated.

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The Washington strain is the most important and valuable one. The Thomson strain is also of value, and the Golden Nugget, Yellow Washington, and Yellow Thomson strains are of possible value for commercial orcharding.

The other eight strains described are probably of little commercial value, and their presence in established orchards is one of the principal causes of the low and poor production of many of them.

The undesirable strains usually have been propagated unintentionally by reason of a lack of knowledge of their existence and importance.

All of the strains described can be isolated through bud selection based on individual-tree performance records. Fruit-bearing bud wood, with representative fruits attached, should be used for propagation purposes.

Established trees of unproductive and undesirable strains have been top-worked successfully with buds selected from the best trees of the Washington strain. A practical method for locating such trees and a discussion of their treatment in commercial orchards is presented in Farmers' Bulletin 794 of the United States Department of Agriculture, entitled "Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records."

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 624

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER July 25, 1918

CITRUS-FRUIT IMPROVEMENT: A STUDY OF BUD VARIATION IN THE VALENCIA ORANGE.[1]

By A. D. Shamel, *Physiologist in Charge*, L. B. Scott, *Pomologist*, and C. S. Pomeroy, *Assistant Pomologist, Fruit-Improvement Investigations, Office of Horticultural and Pomological Investigations.*

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CALIFORNIA CITRUS VARIETIES.

The commercially important varieties of citrus fruits grown in California are the Washington Navel, the Valencia, and the Mediterranean (*Mediterranean Sweet*) oranges; the Dancy tangerine; the Eureka and Lisbon lemons; and the Marsh (*Marsh Seedless*) grapefruit. Other less important varieties grown only to a limited extent include the St. Michael, Navelencia, Ruby blood, and Malta blood oranges, and the Villafranca lemon. Of the two leading orange varieties the Washington Navel is by far the most widely cultivated, producing an annual crop of about 27,000 carloads of fruit.[2] This variety ripens its fruit from November to June, inclusive. The Valencia ripens its fruit from June to October, inclusive, and produces

[1] This is the second in a series of publications summarizing the citrus-fruit improvement investigations of the Department of Agriculture. The first report of this character was presented in the following publication: Shamel, A. D., Scott, L. B., and Pomeroy, C. S. Citrus-fruit improvement: A study of bud variation in the Washington Navel orange. U. S. Dept. Agr. Bul. 623, 146 p., 16 figs., 19 pl. 1918. In that bulletin the methods of conducting the investigational work are described more in detail than in the present publication.

[2] Wallschlaeger, F. O. The world's production and commerce in citrus fruits and their by-products. Citrus Prot. League, Cal., Bul. 11, p. 70. 1914.

an annual crop of about 8,500 carloads. All other varieties of oranges grown in California produce annually about 4,500 carloads of fruit, ripening their crops mostly in the spring and early summer months. At the present time the increase in the plantings of the Valencia orange in California is greater than that of any other orange variety. For this reason studies of the characteristics of the variety and methods of improving and increasing its production through bud selection during propagation are of special interest.

HISTORY OF THE VALENCIA VARIETY.

The Valencia orange (*Citrus aurantium sinensis* L.) was introduced into California from at least three sources at about the same time. According to William Wood,[1] horticultural commissioner of Los Angeles County, A. B. Chapman and George H. Smith, of that county, received an unlabeled package of orange trees from Thomas Rivers, of London, England, in 1876. Mr. Chapman planted these trees in the nursery on his ranch at San Gabriel, Cal. Buds were propagated from all of these trees and grown until they came into bearing. The only variety which proved to be of value was one which Mr. Chapman called Rivers Late. Col. J. H. Dobbins, of San Gabriel, secured buds of this variety, and when the trees propagated from these buds came into bearing a shipment of the fruit was sent to eastern markets. These oranges brought $4 per box. As a result of this experience the variety became very popular and was widely planted by citrus growers. At that time a citrus grower from Valencia, Spain, was shown the fruit and identified it as the variety called in Spain "La Naranga Tarde de Valencia." Mr. Chapman adopted this name, and it has since been called the Valencia Late, or, more commonly, the Valencia orange.

The other sources of trees of this variety were introductions into California from Florida by several southern California nurserymen, particularly Frost and Burgess[2] and Twogood and Cutter, located at Riverside. The variety had been introduced into Florida by two different persons. About 1870 General Sanford, of Palatka, Fla., obtained a variety of orange from the Rivers nurseries. This variety was labeled Brown.[3] Shortly after the Sanford introduction Mr. E. H. Hart, of Federal Point, Fla., introduced the variety into Florida from the Parsons nursery of Flushing, N. Y.[4] The Parsons nurseries had received the trees from the Rivers nurseries. In shipping the trees to Florida the label was lost. When these trees fruited Mr. Hart exhibited samples of the fruit at a meeting of the Florida State

[1] Letter from Mr. William Wood, Los Angeles, Cal., Jan. 5, 1916.

[2] Letter from Mr. George Frost, Riverside, Cal., Jan. 20, 1916.

[3] Statement received from Mr. Daniel Houston, Zellwood, Fla., May 9, 1916. Mr. Houston was formerly manager of General Sanford's properties.

[4] Letter of Mr. E. H. Hart to Prof. E. H. Van Deman, U. S. Department of Agriculture, Apr. 25, 1888.

Horticultural Society and the nomenclature committee of that society gave them the name Hart's Tardiff, which was successively changed to Hart's Tardy and Hart's Late. The American Pomological Society has adopted the name Hart for this variety, but the names mentioned above are still in common use by nurserymen and growers in Florida. On comparison, the fruits of the Hart introduction were found to be identical with those grown by General Sanford under the name Brown.[1] Budded trees of both the Sanford and Hart introductions were included in the earlier shipments of trees from Florida to California.[2] It was soon found, however, that the Brown, Hart, and Valencia were the same variety, and as it seemed probable that the California Valencia Late and the Florida introductions were nearly related and came from the same original source, the name Valencia is used in California to designate all trees which have descended from these different introductions. Orchards grown from trees or buds received from these sources show only minor differences, if any, and when present these are of such a character as may be due to local soil and climatic conditions rather than to inherent varietal differences. As a rule, the Chapman introduction of Valencia orange has a more globular shape than the Florida strains and is said to ripen somewhat earlier. The Chapman trees usually are more upright in habit of growth than those of the Florida Valencia, but not enough reliable information is available regarding this or other comparative varietal tree and fruit characters of these introductions for any final conclusions as to inherent differences between them.

The performance records of individual trees and the observations, illustrations, and notes of trees and fruits contained in this bulletin have all been obtained from trees which trace back to the Florida introductions now commonly known in California as the Valencia orange. These records and observations have been made in the orchards of southern California and for the most part in those located in Riverside County.

VARIABILITY WITHIN THE VARIETY.

Previous to this study it had been generally supposed that one Valencia tree was as good as another and that for a series of years they would produce practically equivalent crops. Contrary to this, these investigations have proved that instead of the Valencia variety being stable and constant, it is composed of several distinct strains which differ from each other in many characters of fruit and tree. The term "strain" is used here to designate a group of individuals of a horticultural variety which differ from all other indi-

[1] Letter of Mr. E. H. Hart to Prof. E. H. Van Deman, U. S. Department of Agriculture, June 10, 1887.
[2] Statement received from Mr. Daniel Houston, Zellwood, Fla., May 9, 1916.

viduals of the variety in one or more constant and recognizable characteristics and which are capable of perpetuation through vegetative propagation. Within the various strains there are variations in the amount and commercial quality of the fruits produced by the individual trees. The variability of individual-tree production in the orchard as regards quantity, commercial quality, time of ripening, and other characteristics is of the highest importance to growers of fruit varieties.

The variability of the trees and fruits within the variety is of fundamental significance from the standpoint of the grower and in any study of the conservation and stabilization of the variety as a whole.

The Valencia strains are distinguished by differences in habits of growth, time of ripening fruits, quantity and quality of crops, and other definite and marked characteristics. The trees of certain strains were found to have upright habits of growth, while those of other strains are drooping or spreading. The trees of some of the strains produce, as a rule, full crops of the best-grade fruit, while those of other strains produce light crops of low-grade fruit. The trees of at least one of the strains produce early-ripening crops, while those of other strains produce later ripening fruits. The leaves of the trees of some of the strains are large, broad, and bluntly rounded in shape, while trees of other strains have small, narrow, and sharply pointed leaves.

In many cases, fruits of two or more of the different strains have been found on the same tree grown from a single bud and therefore upon the same individual stock. Such instances have shown the fallacy of the theory that the different strains are variations due to climatic or soil conditions or the influence of different stock. Later, it was found that the different strains occurring in a single tree could be isolated through bud selection in propagation, thus proving that the differences observed were true inherent cases of bud variation.

The mixture of strains in the Valencia orchards under observation was found to be so marked and frequent as to warrant careful investigations of their relative value. The results of these investigations, which have covered more than four years, together with suggestions for the isolation of the best strains of this variety through bud selection and for the stabilization of the variety through the propagation of only the most desirable strains, are set forth in the following pages.

OCCURRENCE AND FREQUENCY OF BUD VARIATIONS.

A casual observation of the Valencia orange trees selected for these investigations will reveal little of the startling condition of bud variability existing in the trees and their fruits. Several Valencia orange growers, with many years of experience in the culture of this

variety, have expressed genuine surprise when some of the bud variations of foliage and fruits occurring on their trees have been pointed out to them. As a matter of fact, while bud variations have been known to exist in trees of this variety for some time, their frequency and importance have not been fully realized until very recently and as a result of these investigations.

Twelve important strains of the Valencia variety have been found and described during these investigations. Several other minor and less frequent variations have been found from time to time, but, so far as is now known, they are of little significance or importance in commercial orchard practice or in the present studies.

The total number of strains existing in the Valencia variety is not known. Additions are continually being made to the list, as knowledge of the variety grows and the extent of the investigations widens to include observations of a larger number of trees.

The extent of the occurrence of diverse strains of the Valencia variety in established bearing orchards has been found to be even greater than the occurrence of similar variations in Washington Navel groves. The percentage of off-type trees, i. e., marked variations from the best or Valencia strain, found in individual commercial orchards is practically the same as was found in Washington Navel orange orchards (from about 10 to approximately 75 per cent),[1] but a larger proportion of the Valencia orchards have shown the higher percentages of trees of variable strains.

The name Valencia has been applied to the best strain of the variety, because, as nearly as can be determined, it is similar in type of tree and of fruit to the original Valencia introductions into California which were propagated on account of their superior quality and productiveness. This strain bears the heaviest crops and the most desirable fruits of any of the strains of this variety under observation. It is the strain upon which the reputation of the variety has been founded and which under present conditions is the most desirable for cultivation in California.

As a rule, the younger Valencia orchards show a larger proportion of trees bearing inferior fruits than the older orchards. This condition indicates that the prevailing methods used in propagating this variety have resulted in the perpetuation of an increasingly large proportion of trees of undesirable strains.

OBJECTS OF THE INVESTIGATIONS.

The objects of the investigations reported in this bulletin are (1) to ascertain the variations which have taken place in the Valencia orange through bud variation and to learn the comparative value of

[1] Shamel, A. D., Scott, L. B., and Pomeroy, C. S. Citrus-fruit improvement: A study of bud variation in the Washington Navel orange. U. S. Dept. Agr. Bul. 623, 146 p., 16 fig., 19 pl. 1918.

the different strains for commercial fruit production; (2) to determine the extent to which undesirable variations have been propagated, as shown by the percentage of such inferior trees in the present bearing groves; and (3) through improved methods of propagation to control the extent to which undesirable variations in the future shall enter into the population of commercial Valencia orange groves. Briefly stated, these investigations have been undertaken for the purpose of discovering practical methods for conserving and stabilizing the Valencia orange variety.

PLAN OF THE INVESTIGATIONS.

The investigations have been carried on by means of individual-tree performance records and observations.

The term "performance record" is here used to designate the record of the quantity and the commercial quality of the fruits borne by an individual tree during one or more years.

The term "performance-record plat" as used in these investigations means a group of trees grown under comparable conditions and selected for the purpose of determining the relative behavior of the trees by means of individual-tree records of production, observations, and descriptive notes.

The primary conditions considered in the location of the performance-record plats of Valencia oranges in which the investigational work was conducted were (1) full-bearing trees planted on virgin land, so as to eliminate all possible influence of previous soil or cultural conditions; (2) uniform soil where little or no fertilizers of any kind had been applied and where uniform cultural treatments had been practiced from year to year; (3) the absence of any radical pruning or other tree treatment; (4) the absence or effective control of insect enemies and diseases; (5) trees in a normal, healthy condition, showing satisfactory vegetative growth; (6) a knowledge of the character of the stocks and the sources of the buds used in propagation; (7) sufficient elevation to assure natural protection from frost and other unfavorable conditions; and (8) the prospect of the control of the orchard by the same owners for a series of years.

These conditions, particularly those of soil and culture, are not conducive to large yields, but are favorable to the study of inherent individual-tree variability and behavior. As the object of these investigations is not the measurement of the highest possible yield or the study of the influence of cultural conditions on the production of large crops, but rather the behavior of trees under conditions as nearly natural as it is possible to secure in commercial citrus orchards in California, it was deemed wise in this selection to eliminate so far as practicable all local environmental influences and abnormal conditions.

The principal plats of Valencia oranges finally selected for individual-tree performance-record work are located in a citrus orchard of approximately 750 acres about equally divided between Valencia oranges, Washington Navel oranges, and Eureka lemons. A study of all the Valencia trees on this ranch was made before the plats of trees for detailed observation were finally selected. This selection was made with the idea of securing a representative lot of trees which would include typical trees of some of the most important strains of the variety. Trees to the number of 115 which had been planted in the fall of 1903 were selected. Actual performance-record work was begun in 1912. Complete annual records secured from 105 of these trees for four successive years are available for study. Later in 1912 a plat of 9 trees of the Valencia strain was selected in another Valencia orchard several miles distant, where soil conditions are markedly different. In 1914 an additional plat of 55 trees was chosen in the same orchard where the first plat was located, mainly for the purpose of studying the individual-tree behavior of the Valencia or best strain of the Valencia variety. In this publication the discussion of results will be confined to those secured from the records obtained from the plat first selected.

METHODS OF KEEPING PERFORMANCE RECORDS.

In securing the individual-tree performance records for investigational purposes[1] each tree is given a number, and the trees in the plats are marked annually with cloth streamers to prevent their being picked accidentally by the regular picking crew of the ranch. Each tree is picked separately, and all notes concerning the quantity and quality of fruit borne by that tree are recorded before the picking of the next tree is begun.

The fruits are assorted into three grades: (1) An Orchard grade, including all of the valuable first-class commercial fruits; (2) a Standard grade, including marked, misshapen, unevenly colored, or other blemished fruits which are distinctly of a second class in commercial quality, but still worthy of marketing; and (3) a Cull grade, consisting of fruits of such inferior quality as to be wholly unfit for the market. By means of a small mechanical sizer, similar to those in actual use in orange-packing houses, the fruits in the Orchard and Standard grades are sized into the commercial sizes varying from 288 to 80. The fruits of each size in each grade are counted and weighed and the notes recorded on forms arranged especially for this

[1] For a complete description of the methods followed in securing the investigational performance records see the following publication: Shamel, A. D., Scott, L. B., and Pomeroy, C. S. Citrus-fruit improvement: A study of bud variation in the Washington Navel orange. U. S. Dept. Agr. Bul. 623, 146 p., 16 fig., 19 pl. 1918.

Directions for securing performance records as a part of commercial orchard picking operations are presented in the following publication: Shamel, A. D. Citrus-fruit improvement: How to secure and use tree-performance records. U. S. Dept. Agr., Farmers' Bul. 794, 16 p., 4 fig. 1917.

purpose.[1] The culls are not sized, but their number and weight are recorded.

The field notes are transferred to annual record sheets, illustrations of their use being shown in the upper part of section A of Table III, and these notes in turn are transferred to period record sheets, illustrations of the use of which are shown in other parts of the same table. Thus the record of each tree is assembled in one place for comparative study.

DESCRIPTIONS OF SOME OF THE IMPORTANT STRAINS.

In addition to the performance records, as opportunity permits descriptive notes are secured of typical trees and fruits of the different strains. Inasmuch as the greatest commercial importance lies in the character of the fruits, the main emphasis in these records is placed upon the characteristics of the fruits of the important strains and their relative commercial value.

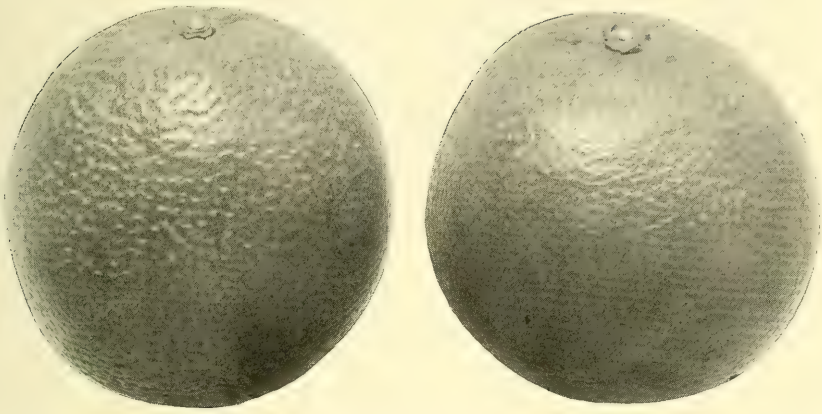
Brief descriptions of some of the important Valencia strains arising from bud variations which have been found in the investigational performance-record plats are here given.

VALENCIA STRAIN.

The trees of the Valencia strain vary considerably in regularity of production and as a whole may be divided into three general classes: (1) Regular producers, (2) alternate-season producers, and (3) irregular producers, bearing full crops only at infrequent intervals. This condition indicates that the Valencia strain as here considered is probably made up of several minor strains, which upon further investigation may be classed among the major strains. The trees, as a rule, have an erect and spreading habit of growth, developing open heads with large rounded leaves.

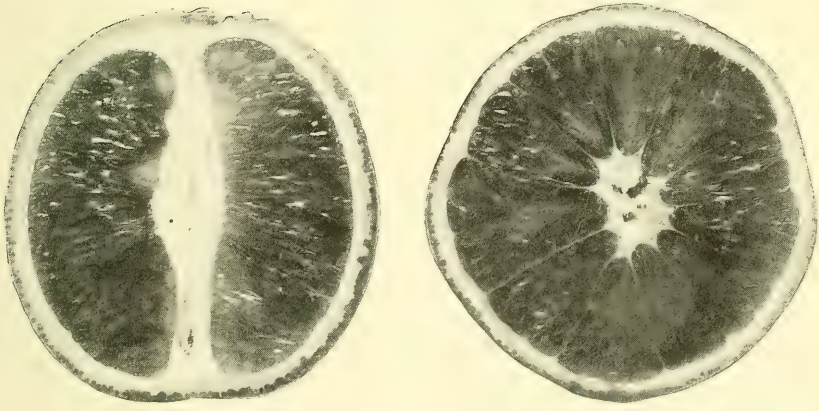
The typical fruits of this strain, illustrations of which are shown in Plate I, are globular, with a tendency to flattened blossom ends; size medium; texture of skin smooth; color bright orange; rind thin; rag tender; juice abundant and sweet; seeds from none to 10, averaging in these observations about 3 per fruit. The fully ripened fruits have a good quality, inferior only to that of the Washington Navel orange among California citrus fruits. Under certain climatic conditions the ripe fruits on the trees are likely to start a new growth, resulting in the fruits turning green in color. This second development of green color is likely to disappear after picking, and its loss can be hastened by increasing the temperature and humidity conditions of the stored fruits.

[1] Shamel, A. D. Citrus-fruit improvement: How to secure and use tree-performance records. U. S. Dept. Agr., Farmers' Bul. 794, tab. I, pp. 10–11. 1917.



P13639HP

FIG. 1.—SIDE VIEWS SHOWING THE CHARACTERISTIC TEXTURE OF THE RIND.

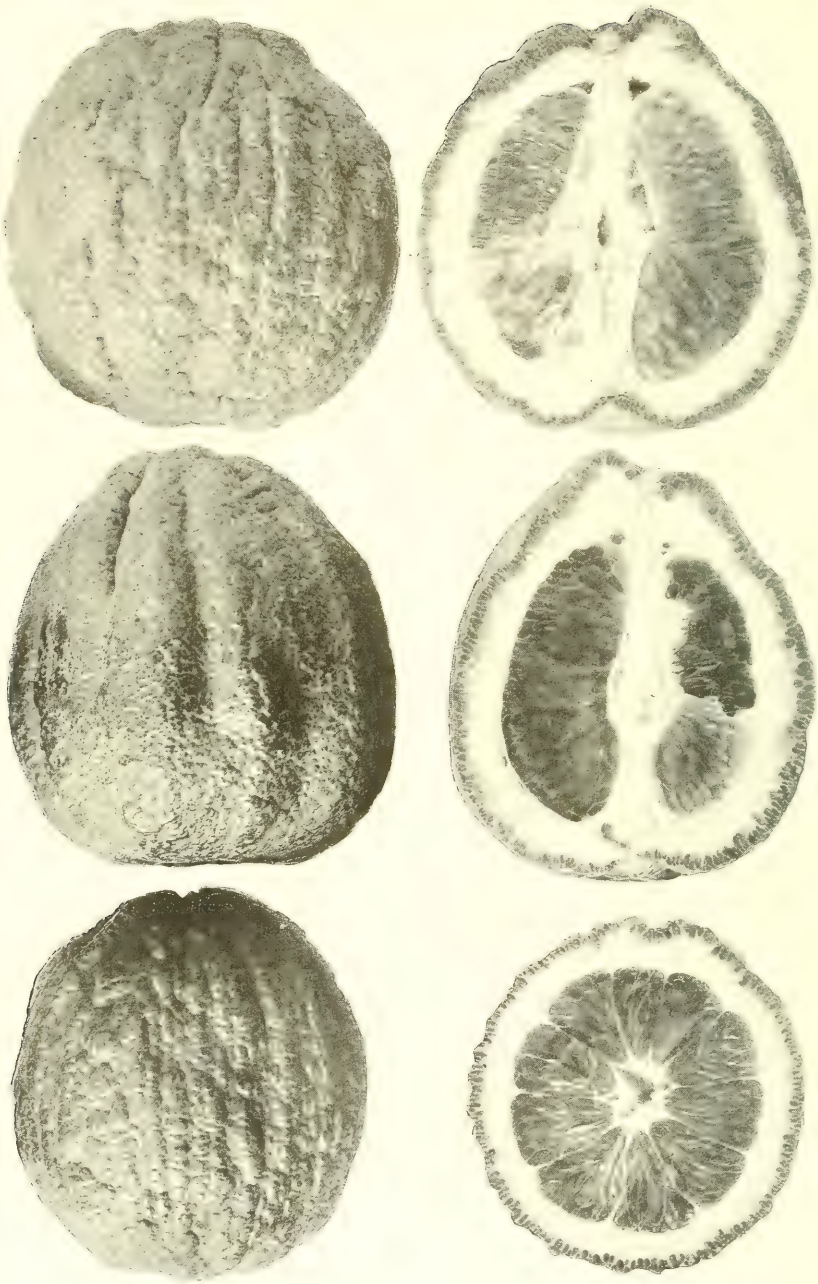


P13640HP

FIG. 2.—AXIAL AND CROSS SECTIONS OF THE SAME FRUITS.

TYPICAL FRUITS OF THE VALENCIA STRAIN OF THE VALENCIA ORANGE.

(About three-fourths natural size.)



P240A–HP AND P241A–HP

TYPICAL FRUITS OF THE CORRUGATED STRAIN OF THE VALENCIA ORANGE. TWO VIEWS ARE SHOWN OF THREE FRUITS.

(About two-thirds natural size.)

P9137HP

FIG. 1.—SIDE VIEW OF THE FRUITS, SHOWING THEIR CHARACTERISTIC CYLINDRICAL SHAPE.

P9138HP

FIG. 2.—CROSS AND AXIAL SECTIONS OF THE SAME FRUITS.

TYPICAL FRUITS OF THE LONG STRAIN OF THE VALENCIA ORANGE.

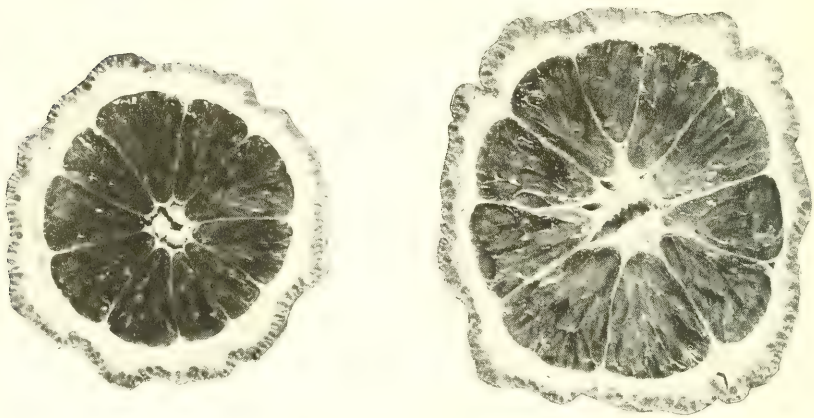
(About four-fifths natural size.)

P9122HP

FIG. 1.—SIDE VIEW, SHOWING THE SHAPE OF THE FRUIT AND ITS CHARACTERISTIC RIBBED SURFACE.

P9121HP

FIG. 2.—ENDS OF THE SAME FRUITS.



P9123HP

FIG. 3.—CROSS SECTIONS OF THE SAME FRUITS.

TYPICAL FRUITS OF THE RIBBED STRAIN OF THE VALENCIA ORANGE.

(About nine-tenths natural size.)

CORRUGATED STRAIN.

The trees of the Corrugated strain are not so productive, as a rule, as those of the Valencia strain. They have a drooping habit of growth, and the leaves are usually smaller than those of the Valencia strain and are sharply pointed.

The typical fruits, as shown in Plate II, are oblong or cylindrical; size usually large; texture of skin very rough, corrugated; rind thick; color greenish; rag tough; juice scant, of poor quality and flavor; seeds averaging 2 or 3 per fruit; in fact, these fruits are not worth shipping to eastern markets, but in these investigations they have been included in the standard grade for this variety. This strain, however, is one of the most interesting in the variety for purposes of studying the behavior of bud mutations in citrus fruits.

LONG STRAIN.

The habit of growth and foliage characteristics of the Long strain are similar to those of the Valencia strain, but the trees are less productive.

The fruits, as shown in Plate III, are cylindrical and much longer than those of other strains; size, as measured by cross diameter, small to medium; texture smooth; color bright orange; rag tender; juice abundant, sweet, of good quality; seeds averaging 1 or 2 per fruit. The peculiar shape of these fruits makes them unsuitable for packing and marketing under prevailing conditions. This strain frequently occurs as limb sports in trees of the Valencia strain.

RIBBED STRAIN.

The trees of the Ribbed strain are usually very irregular in production, bearing full crops some seasons, followed by several seasons of very light production. The habit of growth is usually drooping, and the foliage is sparse, the leaves being small and sharply pointed.

The typical fruits, as shown in Plate IV, are globular, sometimes somewhat flattened on both stem and blossom ends; size small; texture coarse; color pale yellow; rind thin to medium; rag tender; juice abundant, inferior in quality and flavor to that of the fruits of the Valencia strain; seeds averaging 2 per fruit. The ribbed character of the rind gives the fruits a striking appearance, but it detracts from their commercial value under prevailing market conditions.

YELLOW STRAIN.

The productiveness of the trees of the Yellow strain is about the same as those of the Ribbed strain, except that they show a tendency to more regularity of annual production. The habit of growth is spreading and drooping. The foliage is of medium density, the leaves being medium in size and sharply pointed.

The typical fruits, as shown in Plate V, are globular; size small; texture very smooth; color deep yellow; rind very thin; rag very tender; juice abundant, very sweet; seeds averaging 1 per fruit. Frequently the skins of these fruits have small spots or streaks of red, as is the case with the fruits of the Yellow strain of the Washington Navel orange. On account of the small size and yellow color of the fruits, they are inferior to fruits of the Valencia strain for commercial purposes under prevailing conditions. These fruits usually ripen about one month earlier than those of the Valencia strain, and for this reason may prove to be of value for some climatic and soil conditions. They are very frequently found as limb sports in trees of the Valencia or other strains.

SMOOTH STRAIN.

The trees of the Smooth strain are much less productive than those of the Valencia strain, and have an upright, spreading habit of growth. The foliage and other tree characteristics are similar to those of trees of the Valencia strain.

The fruits, illustrations of which are shown in Plate VI, are usually somewhat smaller than the fruits of the Valencia strain, but have about the same shape; texture of skin very smooth, resembling in appearance that of fruits of the Smooth strain of the Washington Navel orange; color reddish orange; rind very thin; rag tender; juice abundant, sweet; seeds averaging 2 or 3 per fruit. This strain is promising as a valuable addition to the orange strains in California when isolated and improved by bud selection. It is frequently found as a limb sport in trees of the Valencia strain.

BARREN STRAIN.

The trees of the Barren strain show more than ordinary vegetative vigor, are very unproductive, and have a drooping habit of growth and very finely branched, dense foliage. The leaves are usually small, narrow, and very sharply pointed. One interesting condition of tree behavior in this strain is the tendency to produce an unusually large number of flowers during the blooming period.

The typical fruits occasionally produced by some trees of this strain, as shown in Plate VII, are flattened in shape, usually with a wrinkled appearance around the stem; size small; texture coarse; color yellowish orange; rind very thick; rag excessive, tough; juice scant, of very inferior quality; seeds averaging 1 or 2 per fruit. On account of its low production and the inferior commercial quality of its fruits, this strain is absolutely worthless. It is occasionally found as a limb sport in trees of the Valencia strain.

ROUGH STRAIN.

The trees of the Rough strain show more than ordinarily vigorous vegetative growth, with a tendency toward the production of a large number of suckers or abnormal branches, and bear smaller crops than trees of the Valencia strain. The habit of growth is usually upright and the foliage dense with large leaves. The large proportion of trees of this strain found in some Valencia orchards is probably due to the use of sucker growth in propagating the trees.

The typical fruits, as shown in Plate VIII, are globular; size large; texture coarse and rough; color yellowish orange; rind thick; rag tough; juice medium in quantity and quality; seeds averaging 2 or 3 per fruit. On account of the inferior appearance of these fruits they are of much less commercial value than those of the Valencia strain. They are occasionally found as limb sports in trees of the Valencia strain.

SPORTING STRAIN.

The trees of the Sporting strain are very variable in habit of growth and production, are usually of more than ordinarily vigorous vegetative growth, and have rather dense foliage. The leaves are extremely variable in size and shape.

The fruits, examples of which are shown in Plate IX, vary in a manner similar to the tree characteristics and frequently include examples of all of the observed strains of the variety and an unusual number of other forms, such as those showing raised or sunken sections, or both, sections of different strains of the Valencia oranges, peculiar ridges or depressions, and abnormal shapes. Usually but few fruits of the Valencia strain are borne by these trees, and on the whole, their crops are of very inferior value from a commercial standpoint.

FLAT STRAIN.

The trees of the Flat strain are comparatively unproductive, with an erect habit of growth and sparse foliage. The leaves are usually small and sharply pointed.

The typical fruits of this strain, as shown in Plate X, are distinctly flattened at both the stem and blossom ends, giving them a very characteristic appearance; size medium; texture coarse; color yellowish orange; rind thick; juice scant, of inferior quality; seeds averaging about 3 per fruit. On account of their shape, these fruits are not suitable for packing under prevailing conditions of marketing. This strain is frequently found as limb sports in trees of the Valencia strain.

NAVEL STRAIN.

The trees of the Navel strain have habits of growth and production similar to those of the Valencia strain. The foliage is usually rather dense; the leaves are small and rather pointed in shape.

The typical fruits, as shown in Plate XI, resemble the fruits of the Valencia strain in shape, size, and color, but differ from them in having a smoother texture of skin, thinner rind, more acid juice, fewer seeds, and a small, often rudimentary navel. This strain occurs occasionally as individual fruit and limb sports in trees of the Valencia strain. It has been isolated in commercial propagation and is grown to a limited extent under the name Navelencia orange. This strain is especially interesting from the fact that there is a possibility of isolating from it by bud selection a seedless strain of the Valencia variety.

WILLOW-LEAF STRAIN.

The trees of the Willow-Leaf strain have spreading and drooping habits of growth, very narrow, willowlike leaves, and produce infrequent, light crops of fruit.

The typical fruits, as shown in Plate XII, are somewhat flattened; size usually small; color yellowish; texture of skin very coarse; rind thick, ridged, and uneven; rag coarse; juice scant, of poor quality; seeds averaging about 2 per fruit. This strain, while one of the most interesting bud variations found in this variety, is absolutely worthless for commercial purposes.

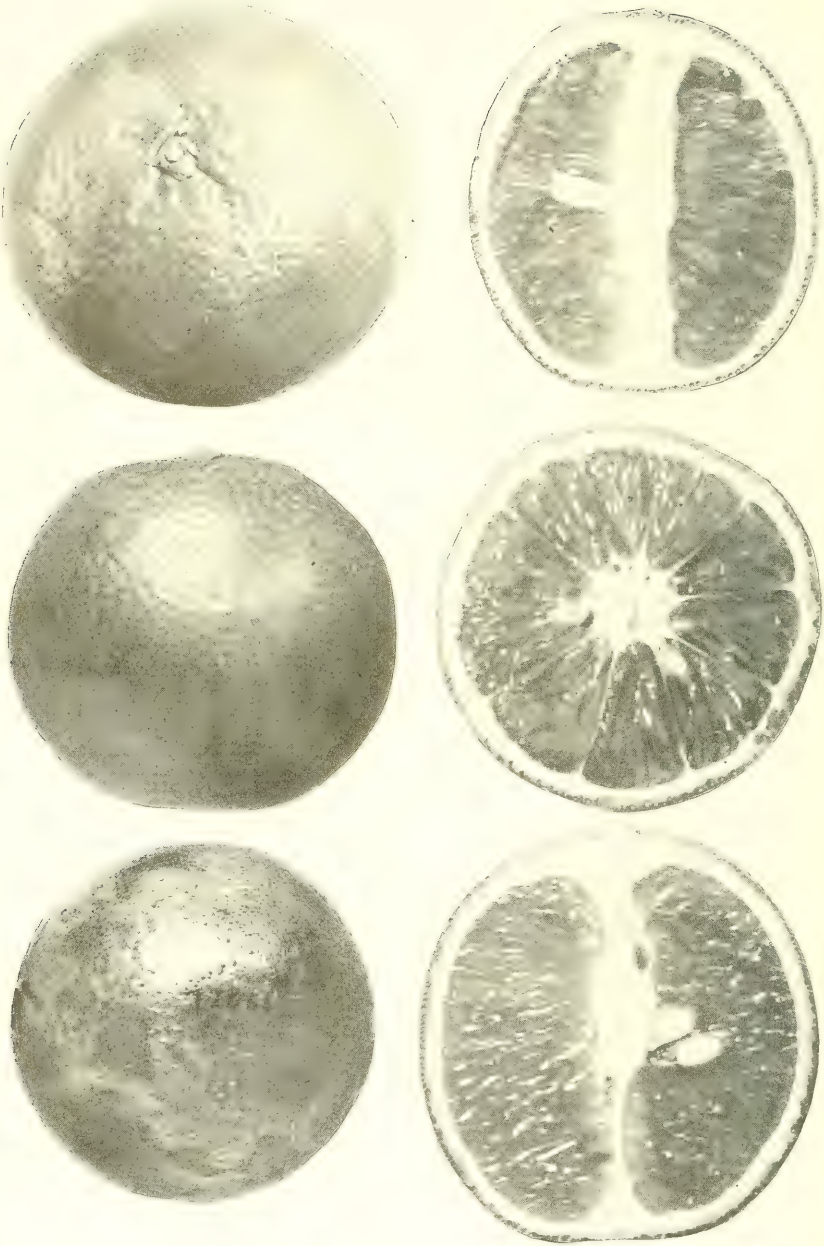
INDIVIDUAL VARIATIONS OF FRUITS.

The individual fruit variations found in trees of many of the Valencia orange strains are of fundamental importance in considering the origin of the various strains and their widespread distribution in young orchards. Under normal conditions a twig originating as a bud variation and bearing only a single variable fruit will in a few years develop into a large branch bearing the same character of fruit. In securing bud wood for propagation according to the methods which have prevailed in the past, no thought has been given to the possible occurrence in the trees of branches bearing fruits of variable strains, and as a result among trees so propagated there is usually found a considerable proportion of variable ones. On account of this previous lack of knowledge of the existence of variable strains, the percentage of such variable-strain trees in the population of any locality has been greatly increased with each bud generation. This fact is one of the most important reasons for securing individual-tree performance records and using such records as guides in the selection of trees from which to obtain bud wood for propagation.

P9379HP

TYPICAL FRUITS OF THE YELLOW STRAIN OF THE VALENCIA ORANGE, SHOWING ITS SHAPE, THE THICKNESS AND TEXTURE OF THE RIND, AND OTHER CHARACTERISTICS.

(About three-fourths natural size.)



P1018A–HP AND P9295HP

TYPICAL FRUITS OF THE SMOOTH STRAIN OF THE VALENCIA ORANGE.

(About four-fifths natural size.)

P1148HP

TYPICAL FRUITS OF THE BARREN STRAIN OF THE VALENCIA ORANGE, SHOWING THE CHARACTERISTIC COARSE TEXTURE OF THE RIND AND ONE VARIABLE FRUIT.

(About three-fifths natural size.)

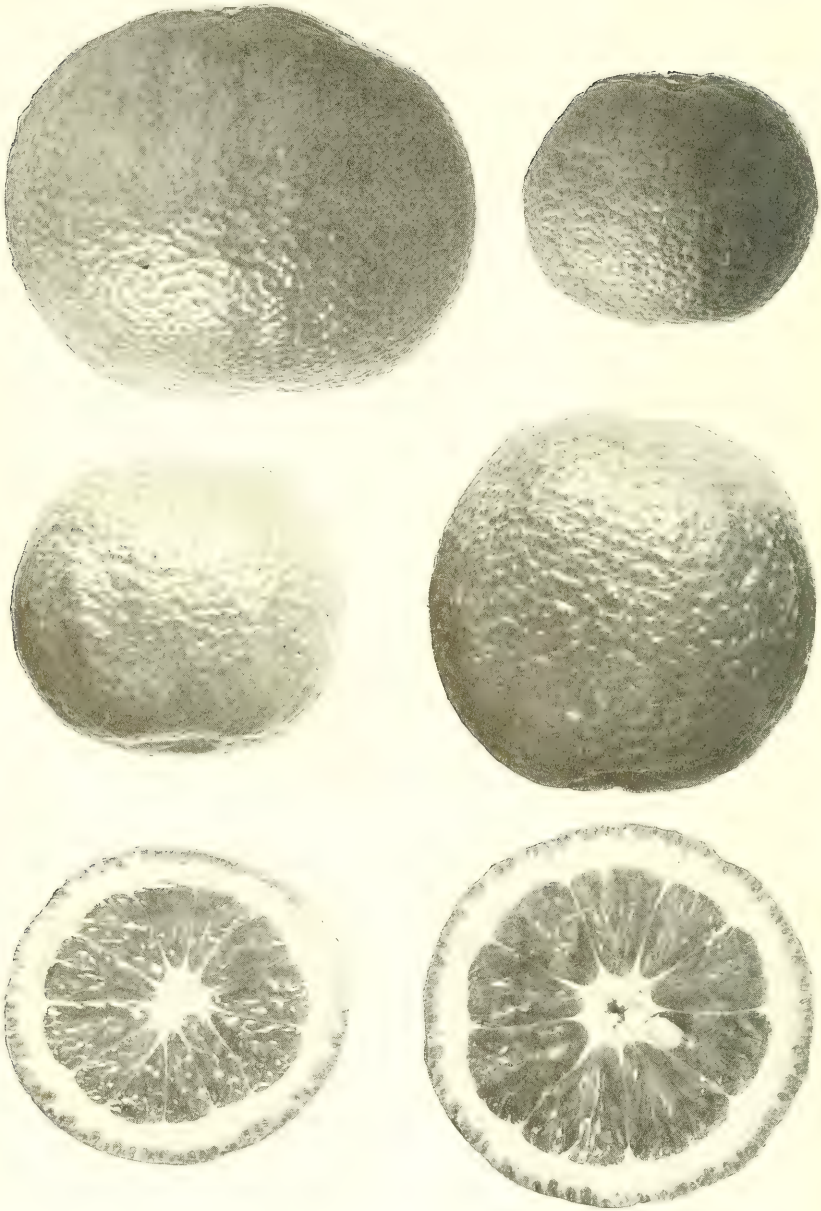
P9376HP

TYPICAL FRUITS OF THE ROUGH STRAIN OF THE VALENCIA ORANGE.

(About three-fifths natural size.)

FRUITS OF THE SPORTING STRAIN OF THE VALENCIA ORANGE, ALL BORNE ON ONE TREE GROWN FROM A SINGLE BUD.

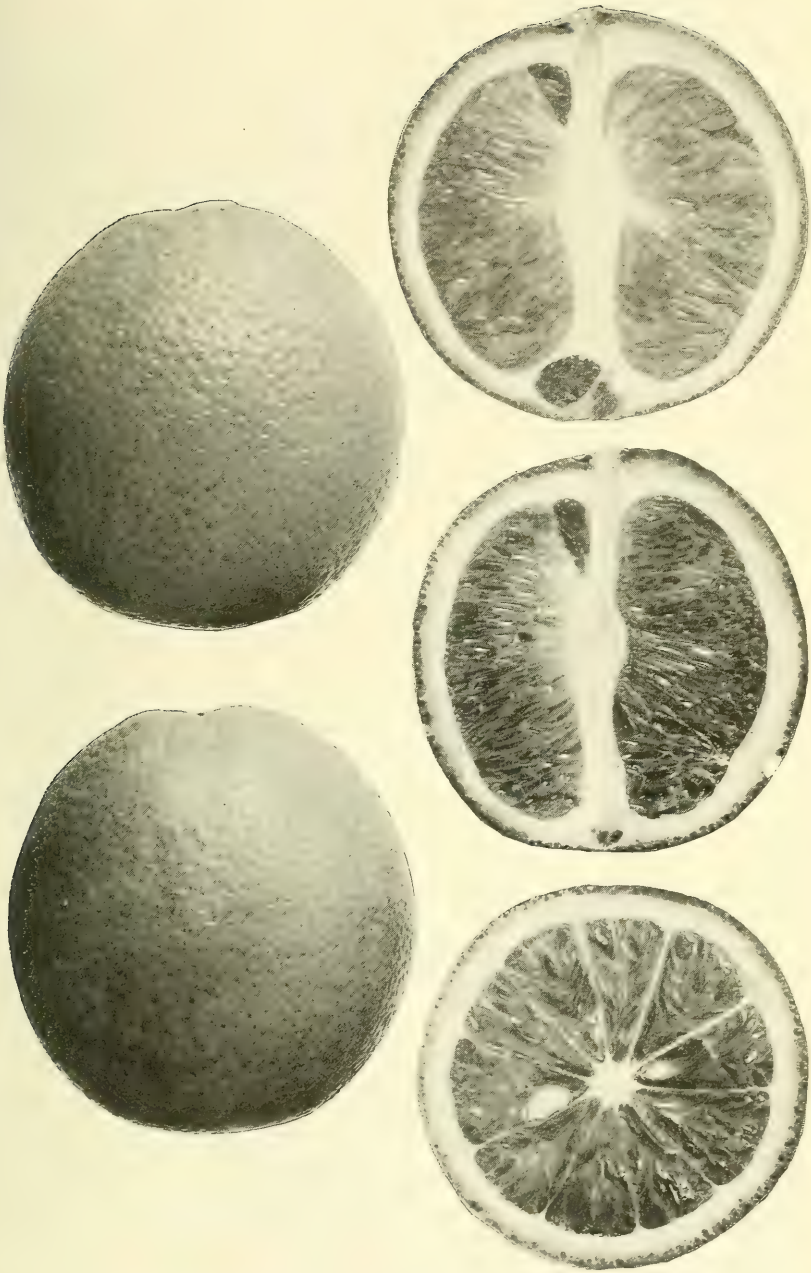
1, Valencia strain; 2, Rough strain; 3, Flat strain; 4, Flat strain, corrugated; 5, Long strain; 6, Sunken section; 7, Raised section; 8, Ribbed strain; 9, Ridged section. (One-half natural size.)



P238A–HP, P1196A–HP, AND P1199A–HP

TYPICAL FRUITS OF THE FLAT STRAIN OF THE VALENCIA ORANGE.

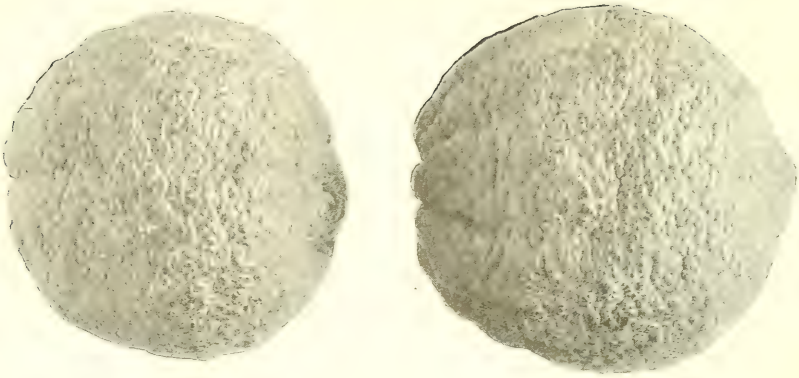
(About four-fifths natural size.)



P134A-HP

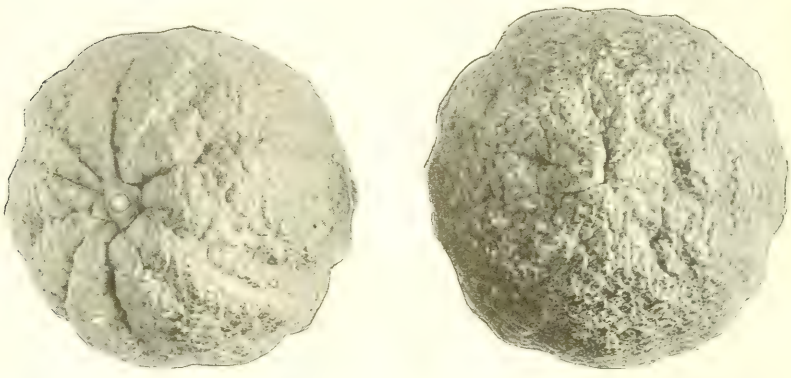
TYPICAL FRUITS OF THE NAVEL STRAIN OF THE VALENCIA ORANGE.

(About four-fifths natural size.)



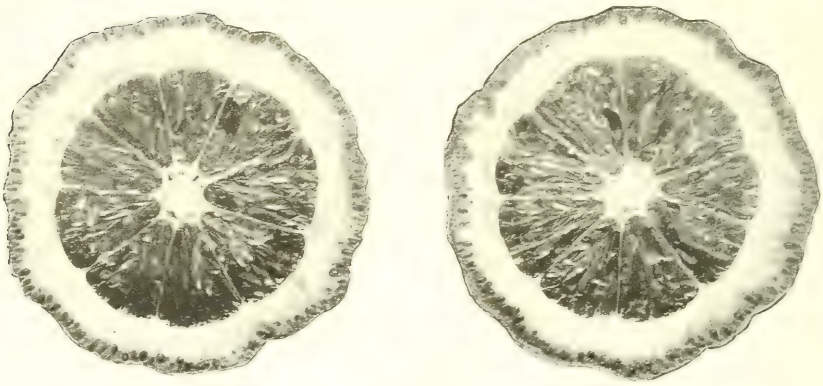
P214A–HP

FIG. 1.—SIDE VIEWS, SHOWING THE COARSE, ROUGH TEXTURE OF THE RIND.



P213A–HP

FIG. 2.—END VIEWS OF THE SAME FRUITS.

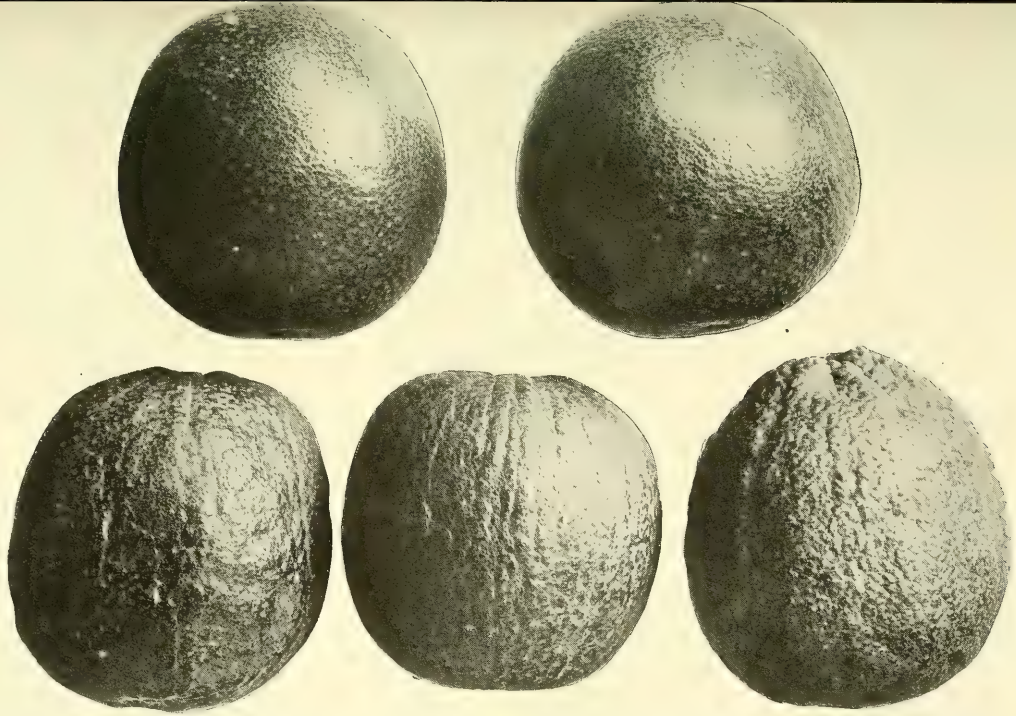


P215A–HP

FIG. 3.—CROSS SECTIONS OF THE SAME FRUITS.

TYPICAL FRUITS OF THE WILLOW-LEAF STRAIN OF THE VALENCIA ORANGE.

(About two-thirds natural size.)



P1174A–HP

TYPICAL FRUITS OF THE VALENCIA AND ROUGH STRAINS OF THE VALENCIA ORANGE BORNE ON ONE TREE GROWN FROM A SINGLE BUD.

The Rough-strain fruits were produced on a sporting limb, the remainder of the fruits on the tree being typical Valencia strain in character. (About three-fifths natural size.)

P458A–HP

MINOR VARIATIONS OF FRUITS BORNE ON A TREE OF THE VALENCIA STRAIN GROWN FROM A SINGLE BUD.

1 and 2, Valencia strain; 3, Raised section; 4, Sunken section; 5, Raised and Sunken sections; 6, Rough strain. (About seven-tenths natural size.)

Fruits arising from bud variations may occur as individual fruits, or collectively on a single branch, or on several branches of a single tree. Plate XIII shows fruits of the Rough strain which were borne on a sporting limb in a Valencia strain tree. The degree of fruit variability considered in this connection, while often of importance commercially, is usually not sufficient for varietal distinction. It may be illustrated by the variability of fruits in the Washington Navel orange where the variations under observation are well marked and commercially distinct but all of the fruits possess the characteristic navel. These strains possess characteristics which have been found to be capable of isolation through bud selection in propagation. The differences in the characteristics of the fruit variations in some of the different strains are of an importance from the commercial standpoint almost equal to those which differentiate the horticultural varieties of the citrus fruits.

The number of major fruit variations borne by individual Valencia trees in the performance-record plats differs greatly. A few trees have been found in the performance-record plats without any apparent or marked variations in fruits other than the usual modifications of size, shape, texture of rind, color, or quality which are probably due to the influence of environmental conditions. In some trees one or only a few variable fruits have been found. In others, several fruits of each of the 12 distinct strains have been found borne by one tree grown from a single bud. In some trees one of the main branches occasionally is found to bear fruit of several distinct strains, but as a rule single large off-type branches bear fruits of the same general character.

MINOR VARIATIONS OF FRUITS.

A great many minor variations have been found from year to year in some of the performance-record trees. A single fruit often shows sections or segments characteristic of two or more distinct strains of the variety. Others show large raised or sunken sections, or both, in the same fruit, examples of which are shown in Plate XIV. Many abnormal fruits, particularly in shape, have been found and described. Twin fruits, and those showing several divisions, each a complete orange in itself, have been found occasionally.

A careful study of these differences arising from bud variations is being made with the hope that the results will throw some light upon the problems of heredity in citrus varieties.

LESSONS TAUGHT BY THESE INVESTIGATIONS.

The tables and diagrams presented herewith are all prepared from records covering the 4-year period, 1912 to 1915, inclusive, secured from 105 trees in a grove which was planted in the fall of 1903. In

this plat there are typical trees of 8 of the 12 most important strains of the Valencia variety and 3 of the minor strains, as follows: 75 Valencia strain trees; 8 Unproductive; 7 Corrugated; 3 Sporting; 3 Coarse; 2 Rough; 2 Smooth; 2 Barren; 1 Long; 1 Yellow; and 1 Small Yellow. Examples of the other 4 important strains and several minor variations occur as bud and limb sports in many of the trees. Although this plat is not an example of extreme variation of strain in established orchards, it is interesting to note that only 71 per cent of the trees in it are of the Valencia strain. Groves have been observed which were found to contain as large a percentage, and in some extreme cases more than this proportion, of trees other than those of the Valencia strain.

The accompanying performance records, descriptions, and illustrations only partially present the characteristics of the various strains. The real differences of the trees and fruits must be seen and studied personally before they can be fully appreciated and their importance in commercial fruit growing understood. For this same reason, the selection of trees from which to secure bud wood for propagation should not be made on the basis of the performance records of the trees alone. It is most desirable that the final choice be made in the orchards with the performance records in hand by someone who through close study and observation of the trees themselves has gained an intimate knowledge of the interrelation of tree characteristics and crop production.

PRESENTATION OF DATA.

The complete 4-year performance records of the 105 trees on which comparable data have been secured are presented in Table I. This shows the production by weight and number of fruit of each grade and size for each year and the annual average production for the 4-year period. The basis of ranking the trees in this table is the average annual total crop of each tree, expressed in pounds and ounces, without regard to the grade, quality, or uniformity of the fruit. Hence, the position of any particular tree in this table is not necessarily a true index of what its relative position would be if the classification were made on the basis of the commercial value of its fruit. The impossibility of making an accurate classification of a large number of trees on the basis of the comparative quality of the fruits and the desirability of the individual trees is the reason for the adoption of the weight of the average annual crop as a basis in preparing this table.

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive.*

[The weights of annual production are expressed in pounds and ounces, but the fractional averages are expressed decimally in pounds. The fruits of the Standard grade from the trees of the Corrugated and Rough strains were not sized in the years 1912 and 1913.]

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
1, tree No. 23-87-1, Valencia strain:																								
Orchard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	144 10	343	3 12	14	15 10	48	13 15	38	45 1	109	31 12	69	28 1	55	0 8	1	2 7	4	3 8	5	0 0	0	0	....
1913	122 5	407	43 10	177	41 5	133	13 15	40	17 14	45	3 2	7	2 7	5	0 0	0	0 0	0	0 0	0	0 0	0	1.67	....
1914	165 9	458	50 1	168	49 3	137	38 12	95	16 14	37	8 10	17	2 1	4	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	176 11	529	23 3	87	40 2	133	45 8	135	52 11	139	12 13	30	2 6	5	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
Average	152.3	434	30.2	112	36.6	113	28.0	77	33.1	83	14.1	31	8.7	17	0.1	0.3	0.6	1	0.9	1	0	0	2.59	....
Standard grade—																								
1912	64 2	141	1 7	5	4 7	13	8 0	21	15 11	36	11 0	23	15 3	29	1 1	2	7 5	12	0 0	0	0 0	0	1.33	....
1913	27 9	120	21 6	101	4 7	14	1 12	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.33	....
1914	25 13	74	8 2	32	5 1	15	2 14	8	2 8	6	1 7	3	2 11	5	0 10	1	2 8	4	0 0	0	0 0	0	4.67	....
1915	27 11	96	10 5	43	9 6	31	5 2	15	2 6	6	0 0	0	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
Average	36.3	108	10.8	45	5.8	18	4.4	12	5.1	12	3.1	7	4.8	9	0.4	0.8	2.5	4	0	0	0	0	3.25	....
Cull fruits—																								
1912	9 8	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1913	5 6	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
1914	1 8	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1915	4 10	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
Average	5.3	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1 92	....
Total crop—																								
1912	218 4	508	5 3	19	20 1	61	21 15	59	60 12	145	42 12	92	43 4	84	1 9	3	9 12	16	3 8	5	0 0	0	1.00	11
1913	155 4	585	65 0	278	45 12	147	15 11	45	17 14	45	3 2	7	2 7	5	0 0	0	0 0	0	0 0	0	0 0	0	1.89	4
1914	192 14	545	58 3	200	54 4	152	41 10	103	19 6	43	10 1	20	4 12	9	0 10	1	2 8	4	0 0	0	0 0	0	2.78	45

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
1, tree No. 23-87-1, Valencia strain—Continued.																								
Total crop—Continued.	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz*			
1915	209 0	650	33 8	130	49 8	164	50 10	150	55 1	145	12 13	30	2 14	6	0 0	0	0 0	0	0 0	0	0 0	0	4.67	21
Average	**193.8**	**572**	**40.3**	**157**	**42.4**	**131**	**32.5**	**89**	**38.0**	**95**	**17.2**	**37**	**13.3**	**26**	**0.5**	**1**	**3.1**	**5**	**0.9**	**1**	**0**	**0**	**2.58**	20
2, tree No. 23-86-1, Valencia strain:																								
Orchard grade—																								
1912	61 13	135	1 8	6	4 2	13	3 10	10	12 2	29	12 9	27	15 15	31	2 3	4	2 15	5	6 13	10	0 0	0	0	....
1913	130 6	479	70 0	294	35 8	117	11 15	35	10 11	28	2 4	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	126 2	332	34 3	110	33 4	91	26 1	64	16 11	37	10 4	20	5 11	10	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1915	164 4	542	27 5	114	41 5	144	55 11	175	35 15	100	3 0	7	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
Average	120.6	372	33.3	131	28.5	91	24.3	71	18.9	49	7.0	15	5.7	11	0.5	1	0.7	1	1.7	3	0	0	2.92	....
Standard grade—																								
1912	55 1	118	1 5	5	2 12	8	8 12	23	9 2	21	7 2	15	13 10	25	1 1	2	11 5	19	0 0	0	0 0	0	1.33	....
1913	38 15	168	30 2	141	5 2	17	2 13	8	0 6	1	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1914	46 7	125	11 7	42	8 6	24	5 0	13	6 10	16	7 2	15	6 2	12	0 8	1	1 4	2	0 0	0	0 0	0	4.33	....
1915	58 14	229	37 11	161	16 8	55	3 7	10	1 4	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.00	....
Average	49.8	160	20.1	87	8.2	26	5.0	14	4.3	10	3.7	8	4.9	9	0.4	0.8	3.1	5	0	0	0	0	3.43	....
Cull fruits—																								
1912	16 12	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	6 15	52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.67	....
1914	2 4	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1915	5 1	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
Average	7.8	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.50	....

Total crop—																														
1912	133	10	288	2	13	11	6	14	21	12	6	33	21	4	50	19	11	42	29	9	56	3	4	6	14	4	24	6	13	10	0	0	0	.44	6
1913	176	4	699	100	2	435	40	10	134	14	12	43	11	1	29	2	12	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.22	8
1914	174	13	470	45	10	152	41	10	115	31	1	77	23	5	53	17	6	35	11	13	22	0	8	1	1	4	2	0	0	0	0	0	0	3.56	96
1915	228	3	794	65	0	275	57	13	199	59	2	185	37	3	103	3	0	7	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4.59	52
Average	**178.2**		**563**	**53.4**		**218**	**36.7**		**117**	**29.3**		**85**	**23.2**		**59**	**10.7**		**23**	**10.1**		**20**	**0.9**		**2**	**3.9**		**7**	**1.7**		**3**	**0**		**0**	**2.95**	**41**
3, tree No. 23-90-1, Valencia strain:																																			
Orchard grade—																																			
1912	111	1	228	0	4	1	1	11	5	1	14	5	21	1	51	20	14	46	43	9	84	5	12	10	10	13	18	5	3	8	0	0	0	.67	....
1913	111	4	353	30	13	118	38	15	124	21	15	62	17	2	44	0	8	1	1	15	4	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1914	133	14	372	36	4	120	44	11	125	34	6	86	16	1	36	1	7	3	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1915	127	5	401	23	9	87	39	2	130	37	9	112	24	14	67	1	4	3	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
Average	120.9		339	22.7		82	31.2		96	23.9		66	19.8		50	6.0		13	11.9		23	1.4		3	2.7		5	1.3		2		0	0	3.33	....
Standard grade—																																			
1912	79	15	169	2	10	8	2	7	7	7	11	21	14	11	35	14	9	31	19	15	37	3	6	6	14	10	24	0	0	0	0	0	0	1.67	....
1913	43	1	177	30	0	135	8	3	28	4	7	13	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1914	25	14	81	10	8	40	6	5	19	3	2	9	3	6	8	1	7	3	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1915	53	6	189	17	6	70	24	6	85	9	6	28	2	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.97	....
Average	50.6		154	15.1		63	10.3		35	6.2		18	5.1		12	4.1		9	5.3		10	0.8		1.5	3.7		6	0		0		0	0	4.50	....
Cull fruits—																																			
1912	14	13	33																															.33	....
1913	4	14	61																															4.33	....
1914	3	10	19																															2.33	....
1915	2	14	16																															3.97	....
Average	6.5		32																															2.67	....
Total crop—																																			
1912	205	13	430	2	14	9	4	2	12	9	9	26	35	12	86	35	7	77	63	8	121	9	2	16	25	7	42	5	3	8	0	0	0	.89	0
1913	159	3	591	60	13	253	47	2	152	26	6	75	17	2	44	0	15	2	1	15	4	0	0	0	0	0	0	0	0	0	0	0	0	4.33	0
1914	163	6	472	46	12	160	51	0	144	37	8	95	19	7	44	2	14	6	2	3	4	0	0	0	0	0	0	0	0	0	0	0	0	3.78	3
1915	183	9	606	40	15	157	63	8	215	46	15	140	27	2	73	1	4	3	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	4.78	7
Average	**178.0**		**525**	**37.8**		**145**	**41.4**		**131**	**30.1**		**84**	**24.9**		**62**	**10.1**		**22**	**17.1**		**33**	**2.3**		**4**	**6.4**		**11**	**1.3**		**2**	**0**		**0**	**3.45**	**3**
4, tree No. 23-91-1, Valencia strain:																																			
Orchard grade—																																			
1912	114	3	252	0	4	1	5	11	17	8	14	24	25	12	63	24	8	54	32	4	64	3	14	7	11	12	20	1	4	2	0	0	0	2.67	....
1913	115	15	394	47	10	189	39	5	125	17	15	52	8	13	23	2	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1914	146	1	466	81	3	287	39	10	115	22	0	57	2	12	6	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.00	....
1915	107	12	339	20	1	75	32	4	106	32	3	96	20	4	55	2	8	6	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	6.33	....
Average	121.0		363	37.3		138	30.4		91	20.3		57	14.4		37	7.4		17	8.2		16	0.9		2	2.9		5	0.3		0.5	0		0	5.07	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
4, tree No. 23-91-1, Valencia strain—Continued.																								
Standard grade—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	83 6	191	2 10	9	5 12	18	9 9	26	16 12	40	18 6	40	23 15	47	3 5	6	3 1	5	0 0	0	0 0	0	0.67	....
1913	37 7	168	33 2	154	3 7	11	0 14	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1914	28 6	110	20 7	87	5 4	16	1 0	3	1 3	3	0 0	0	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	42 9	149	12 13	53	20 0	68	7 6	22	1 8	4	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	7.00	....
Average	47.9	154	17.3	76	8.6	28	4.7	14	4.9	12	4.8	11	6.1	12	0.8	2	0.8	1	0	0	0	0	4.02	....
Cull fruits—																								
1912	15 10	30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.67	....
1913	5 0	54	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.00	....
1914	3 6	20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2.33	....
1915	3 2	16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7.67	....
Average	6.8	30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3.92	....
Total crop—																								
1912	213 3	473	2 14	10	11 7	35	18 7	50	42 8	103	42 14	94	56 3	111	7 3	13	14 13	25	1 4	2	0 0	0	1.67	0
1913	158 6	616	80 12	343	42 12	136	18 13	55	8 13	23	2 4	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	0
1914	177 13	596	101 10	374	44 14	131	23 0	60	3 15	9	0 8	1	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.33	5
1915	153 7	504	32 14	128	52 4	174	39 9	118	21 12	59	3 6	8	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	7.00	7
Average	**175.7**	**547**	**54.5**	**214**	**37.8**	**119**	**25.0**	**71**	**19.3**	**49**	**12.3**	**27**	**14.3**	**28**	**1.8**	**3**	**3.7**	**6**	**0.3**	**0.5**	**0**	**0**	**4.33**	**3**
5, tree No. 23-86-4, Valencia strain:																								
Orchard grade—																								
1912	106 15	262	5 6	20	10 8	33	12 6	35	27 3	69	19 10	44	21 6	43	2 2	4	6 6	11	2 0	3	0 0	0	.33	....
1913	109 12	413	62 13	264	32 8	108	10 11	31	3 6	9	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
1914	156 4	438	46 1	148	63 1	175	36 0	90	9 12	22	1 6	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	144 1	437	6 2	24	34 1	117	51 3	157	44 13	121	6 15	16	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
Average	129.3	388	30.1	114	35.0	108	27.6	78	21.3	55	7.1	16	5.6	11	0.5	1	1.6	3	0.5	0.8	0	0	3.67	....

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TABLE I. *Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
6, tree No. 23-85-5, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	140 12	303	2 8	10	5 8	17	7 8	20	21 7	51	25 7	55	42 9	82	4 0	7	14 11	25	1 4	2	0 0	0	1.22	29
1913	156 8	620	69 1	299	49 6	162	17 12	51	13 0	34	1 6	3	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	3.56	5
1914	131 12	341	25 14	83	29 9	80	36 8	88	26 10	58	8 3	16	1 9	3	0 0	0	0 11	1	0 0	0	0 0	0	2.78	78
1915	234 12	726	30 6	123	51 14	171	48 3	146	79 9	215	17 4	41	3 4	7	0 8	1	0 0	0	0 0	0	0 0	0	4.78	73
Average	**165.9**	**498**	**32.0**	**129**	**34.1**	**108**	**27.5**	**76**	**35.2**	**90**	**13.1**	**29**	**12.0**	**23**	**1.1**	**2**	**3.8**	**6**	**0.3**	**0.5**	**0**	**0**	**3.09**	**46**
7, tree No. 23-76-24, Valencia strain:																								
Orchard grade—																								
1912	120 12	274	3 8	13	8 4	26	7 4	20	25 6	62	29 6	64	33 0	65	6 14	12	6 7	11	0 11	1	0 0	0	.33	....
1913	128 4	420	46 14	181	43 2	137	17 2	49	17 10	45	3 0	7	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	.67	....
1914	105 0	287	26 8	87	33 10	93	30 6	75	12 0	27	2 8	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.67	....
1915	161 13	417	19 5	34	23 9	75	32 6	93	69 1	177	11 3	25	6 5	13	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
Average	129.0	350	24.0	79	27.1	83	21.8	59	31.0	78	11.5	25	10.0	20	1.7	3	1.6	3	0.2	0.3	0	0	1.50	....
Standard grade—																								
1912	22 0	54	3 2	12	0 10	2	2 9	7	5 12	14	2 5	5	4 10	9	0 9	1	2 7	4	0 0	0	0 0	0	.33	....
1913	29 10	126	25 4	112	1 7	5	2 9	8	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1914	17 12	54	5 6	21	4 10	14	3 4	9	4 0	9	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1915	57 3	179	7 12	33	19 11	66	17 2	49	10 5	26	2 5	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
Average	31.6	103	10.4	45	6.6	22	6.4	18	5.1	13	1.3	4	1.2	2	0.1	0.3	0.6	1	0	0	0	0	3.43	....
Cull fruits—																								
1912	7 5	21																					1.67	....
1913	6 10	81																					3.00	....
1914	2 1	11																					1.67	....
1915	5 4	34																					3.00	....
Average	5.3	37																					2.34	....

Total crop—																																
1912	150	1	349	6	10	25	8	14	28	9	13	27	31	2	76	31	11	69	37	10	74	7	7	13	8	14	15	0	11	1	0	0	0	.78	12
1913	164	8	627	72	2	293	44	9	142	19	11	57	18	0	46	3	0	7	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	2.56	16
1914	124	13	352	31	14	108	38	4	107	33	10	84	16	0	36	3	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.53	46
1915	224	4	630	27	1	67	43	4	141	49	8	142	79	6	203	13	8	30	6	5	13	0	0	0	0	0	0	0	0	0	0	0	0	3.78	30
Average	**165.9**		**490**	**34.4**		**123**	**33.7**		**105**	**28.1**		**78**	**36.1**		**90**	**12.8**		**28**	**11.1**		**22**	**1.9**		**3**	**2.2**		**4**	**0.2**		**0.3**	**0**		**0**	**2.42**	**26**
8, tree No. 23-90-8, Valencia strain:																																
Orchard grade—																																
1912	112	14	235	0	4	1	2	15	9	2	12	8	17	6	43	22	15	51	36	8	73	6	11	12	14	12	25	8	11	13	0	0	0	0	....
1913	100	12	342	34	1	148	28	2	92	15	9	45	17	3	45	3	12	9	1	7	3	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	128	10	358	38	8	126	41	3	116	31	11	79	12	10	28	4	10	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	156	13	426	4	1	14	15	11	50	32	10	96	76	13	203	19	12	46	6	12	15	1	2	2	0	0	0	0	0	0	0	0	0	3.67	....
Average	124.8		340	19.2		72	22.0		67	20.7		57	31.0		80	12.8		29	11.2		23	2.0		4	3.7		6	2.2		3	0		0	2.50	....
Standard grade—																																
1912	62	14	130	1	2	4	2	1	6	4	2	11	11	5	27	11	6	24	18	4	35	1	11	3	12	15	20	0	0	0	0	0	0	1.00	....
1913	23	3	102	17	5	83	3	15	13	1	6	4	0	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1914	17	12	60	9	8	37	3	14	12	2	2	6	1	12	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
1915	26	13	81	1	12	7	10	8	34	9	11	28	3	2	8	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
Average	32.7		93	7.4		33	5.1		16	4.3		12	4.2		10	3.5		7	4.6		9	0.4		0.8	3.2		5	0		0	0		0	4.25	....
Cull fruits—																																
1912	10	12	24																													.33	....
1913	7	7	86																													6.33	....
1914	1	5	7																													2.33	....
1915	1	12	7																													5.33	....
Average	5.3		31																													3.58	....
Total crop—																																
1912	186	8	389	1	6	5	5	0	15	6	14	19	28	11	70	34	5	75	54	12	108	8	6	15	27	11	45	8	11	13	0	0	0	.44	0
1913	130	12	530	51	6	231	31	15	105	16	15	49	17	14	47	3	12	9	1	7	3	0	6	0	0	0	0	0	0	0	0	0	0	4.55	0
1914	147	11	425	48	0	163	45	1	128	33	13	85	14	6	32	5	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	3
1915	185	6	514	5	13	21	26	3	84	42	5	124	79	15	211	21	8	50	6	12	15	1	2	2	0	0	0	0	0	0	0	0	0	4.78	8
Average	**162.6**		**465**	**26.6**		**105**	**27.0**		**83**	**25.0**		**70**	**34.7**		**90**	**16.2**		**36**	**15.7**		**32**	**2.4**		**4**	**6.9**		**11**	**2.2**		**3**	**0**		**0**	**3.44**	**3**
9, tree No. 23-86-10, Valencia strain:																																
Orchard grade—																																
1912	100	4	199	0	10	2	1	5	4	4	0	11	11	13	28	11	14	26	38	12	75	6	5	11	22	5	37	3	4	5	0	0	0	1.33	....
1913	119	10	402	38	11	162	41	15	134	18	2	52	19	8	51	0	7	1	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1914	135	11	393	58	4	191	45	2	124	25	7	63	5	5	12	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1915	162	10	475	9	14	38	21	8	74	44	11	137	71	3	191	12	8	29	2	14	6	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
Average	129.5		367	26.9		98	27.5		84	23.1		66	27.0		71	6.6		15	10.6		21	1.6		3	5.6		9	0.8		1	0		0	3.25	....

TABLE 1.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
9, tree No. 23-86-10, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	32 8	68	0 5	1	1 0	3	3 13	10	6 8	15	7 13	16	5 13	11	1 2	2	6 2	10	0 0	0	0 0	0	0.67	....
1913	25 13	114	19 4	96	3 4	11	1 1	3	0 0	0	0 0	0	1 10	3	0 0	0	0 10	1	0 0	0	0 0	0	3.33	....
1914	15 4	52	9 13	37	3 7	10	1 9	4	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	32 5	107	12 0	46	13 2	42	5 8	15	1 4	3	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	7.00	....
Average	26.5	85	10.3	45	5.2	17	3.0	8	2.1	5	1.1	4	1.9	1	0.3	0.5	1.7	3	0	0	0	0	3.58	....
Cull fruits—																								
1912	12 5	26																					1.67	....
1913	5 1	69																					4.00	....
1914	2 0	12																					3.67	....
1915	2 2	10																					7.67	....
Average	5.4	29																					4.25	....
Total crop—																								
1912	145 1	293	0 15	3	2 5	7	7 13	21	18 5	43	19 11	42	44 9	86	7 7	13	28 7	47	3 4	5	0 0	0	1.22	0
1913	150 8	585	57 15	258	45 3	145	19 3	55	19 8	51	0 7	1	2 9	5	0 0	0	0 10	1	0 0	0	0 0	0	3.67	0
1914	152 15	457	68 1	228	48 9	134	27 0	67	5 12	13	1 9	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.11	6
1915	197 1	592	21 14	84	34 10	116	50 3	152	72 7	194	12 15	30	2 14	6	0 0	0	0 0	0	0 0	0	0 0	0	6.78	1
Average	**161.4**	**482**	**37.2**	**143**	**32.7**	**101**	**26.0**	**74**	**29.0**	**75**	**8.7**	**19**	**12.5**	**24**	**1.9**	**3**	**7.3**	**12**	**0.8**	**1**	**0**	**0**	**3.69**	**2**
10, tree No. 23-86-5, Valencia strain:																								
Orchard grade—																								
1912	100 2	280	10 15	43	20 15	67	17 11	50	28 1	72	12 5	28	6 3	13	1 0	2	1 12	3	1 4	2	0 0	0	1.33	....
1913	136 1	469	63 6	258	43 1	134	13 8	38	10 15	28	3 11	8	1 8	3	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1914	88 1	240	30 0	95	27 8	74	19 14	48	7 10	17	2 0	4	1 1	2	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
1915	147 9	408	3 1	12	11 9	39	36 6	110	73 0	194	17 2	40	5 6	11	1 1	2	0 0	0	0 0	0	0 0	0	7.33	....
Average	118.0	349	26.8	102	25.8	79	21.9	62	29.9	78	8.8	20	3.5	7	0.5	1	0.4	1	0.3	0.5	0	0	4.44	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
11, tree No. 23-86-2, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	152 5	328	2 0	7	7 0	22	8 7	23	26 13	64	34 4	74	40 5	78	6 11	12	13 11	23	4 11	7	0 0	0	0.44	9
1913	155 1	657	92 10	395	34 1	111	10 15	31	6 7	16	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.89	14
1914	140 2	374	27 12	92	41 4	113	33 14	83	23 8	52	8 10	17	0 9	1	1 4	2	1 2	2	0 0	0	0 0	0	2.89	32
1915	194 9	572	18 11	73	36 12	121	52 4	155	57 13	150	21 1	48	3 13	8	1 2	2	0 0	0	0 0	0	0 0	0	5.11	37
Average	**160.5**	**483**	**35.3**	**142**	**29.8**	**92**	**26.4**	**73**	**28.6**	**71**	**16.1**	**35**	**11.2**	**22**	**2.3**	**4**	**3.7**	**6**	**1.2**	**2**	**0**	**0**	3.08	23
12, tree No. 23-90-2, Valencia strain:																								
Orchard grade—																								
1912	98 8	234	3 0	11	8 11	27	9 13	27	26 6	65	18 5	41	26 1	52	2 11	5	2 4	4	1 5	2	0 0	0	0	....
1913	101 14	357	47 9	195	32 14	105	8 15	26	9 13	25	2 3	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1914	111 14	359	71 13	252	24 14	71	10 1	25	2 10	6	1 15	4	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	97 14	289	9 7	36	17 14	59	28 9	85	35 1	93	5 11	13	1 4	3	0 0	0	0 0	0	0 0	0	0 0	0	6.33	....
Average	102.5	310	33.0	124	21.1	66	14.3	41	18.5	47	7.0	16	7.1	14	0.7	1	0.6	1	0.3	0.5	0	0	3.67	....
Standard grade—																								
1912	60 12	148	7 9	27	5 4	16	9 13	27	9 6	22	9 9	20	14 10	28	2 4	4	2 5	4	0 0	0	0 0	0	2.00	....
1913	31 8	142	27 3	129	2 3	7	1 4	4	0 6	1	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1914	31 0	119	21 12	91	7 1	22	1 0	3	1 3	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	56 7	190	11 14	50	23 12	82	11 6	34	6 13	18	2 2	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
Average	44.9	150	17.1	74	9.6	32	5.9	17	4.4	11	3.0	7	3.8	7	0.6	1	0.6	1	0	0	0	0	3.42	....
Cull fruits—																								
1912	38 0	101																					.67	....
1913	6 0	66																					4.00	....
1914	2 8	15																					3.67	....
1915	1 14	10																					4.67	....
Average	12.1	48																					3.25	....

Total crop—																												
1912	197	4	483	10	9	38	13	15	43	19	10	54	35	12	87	27	14	61	40	11	80	4	15	9	4	9	8	1	5	2	0	0	0	.89	23
1913	139	6	565	74	12	324	35	1	112	10	3	30	10	3	26	2	11	6	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.89	4
1914	145	6	493	93	9	343	31	15	93	11	1	28	3	13	9	1	15	4	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	3.89	61
1915	156	3	489	21	5	86	41	10	141	39	15	119	41	14	111	7	13	18	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	5.11	38
Average	**159.5**		**508**	**50.0**		**198**	**30.6**		**97**	**20.4**		**58**	**22.9**		**58**	**10.1**		**22**	**10.9**		**22**	**1.2**		**2**	**1.1**		**2**	**0.3**		**0.5**	**0**		**0**	**3.45**	**32**
13, tree No. 23-85-2, Valencia strain:																												
Orchard grade—																												
1912	141	5	363	6	3	23	21	4	66	21	6	60	52	6	130	20	4	45	17	1	34	1	1	2	1	12	3	0	0	0	0	0	0	1.00	....
1913	119	13	414	48	3	195	44	2	145	13	2	38	11	4	29	1	10	4	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	1.67	....
1914	102	2	298	51	9	167	32	6	88	14	15	36	3	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.00	....
1915	121	13	356	2	13	11	18	7	64	42	1	128	49	12	133	7	4	17	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	6.33	....
Average	121.3		358	27.2		99	29.0		91	22.9		66	29.2		75	7.3		17	5.0		10	0.3		0.5	0.4		1	0		0	0		0	3.75	....
Standard grade—																												
1912	30	10	77	3	4	12	2	6	7	5	10	15	8	3	20	5	15	13	4	1	8	0	0	0	1	3	2	0	0	0	0	0	0	2.33	....
1913	15	4	80	13	15	75	1	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.50	....
1914	32	12	115	24	4	91	5	12	17	1	1	3	1	11	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	46	15	157	16	4	62	21	9	70	7	8	21	0	12	2	0	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.67	....
Average	31.4		107	14.4		60	7.8		25	3.4		10	2.7		7	1.7		4	1.0		2	0		0	0.3		0.5	0		0	0		0	5.13	....
Cull fruits—																												
1912	6	12	21	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.00	....
1913	3	11	55	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	7.00	....
1914	2	0	9	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	4.67	....
1915	2	7	11	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	7.00	....
Average	3.7		24	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	4.92	....
Total crop—																												
1912	178	11	461	9	7	35	23	10	73	27	0	75	60	9	150	26	3	58	21	2	42	1	1	2	2	15	5	0	0	0	0	0	0	1.44	1
1913	138	12	549	62	2	270	45	7	150	13	2	38	11	4	29	1	10	4	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	4.50	2
1914	136	14	422	75	13	258	38	2	105	16	0	39	4	15	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.89	7
1915	171	3	524	19	1	73	40	0	134	49	9	149	50	8	135	8	2	19	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	6.67	7
Average	**156.4**		**489**	**41.6**		**159**	**36.8**		**116**	**26.4**		**76**	**31.8**		**82**	**9.0**		**20**	**6.3**		**12**	**0.3**		**0.5**	**0.7**		**1**	**0**		**0**	**0**		**0**	**4.38**	**4**
14, tree No. 23-87-2, Valencia strain:																												
Orchard grade—																												
1912	120	10	350	16	7	61	35	9	112	22	6	63	35	13	91	8	8	19	1	15	4	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1913	116	4	352	27	8	109	32	15	102	17	15	50	26	0	66	6	15	16	3	2	6	0	0	0	1	13	3	0	0	0	0	0	0	5.33	....
1914	108	15	323	54	2	181	29	13	83	15	6	38	8	10	19	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
1915	121	1	328	2	3	8	15	6	50	31	5	91	47	14	125	17	1	39	5	12	12	1	8	3	0	0	0	0	0	0	0	0	0	5.67	....
Average	116.7		338	24.6		90	28.3		87	21.8		61	29.6		75	8.4		19	2.7		6	0.4		1	0.5		1	0		0	0		0	4.92	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
14, tree No. 23-87-2, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	66 3	178	10 15	38	11 15	36	16 1	43	14 9	35	8 0	17	4 11	9	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1913	20 9	86	14 12	68	3 4	11	1 12	5	0 13	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1914	15 3	50	8 8	31	4 14	14	0 10	2	0 12	2	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1915	30 4	94	4 0	17	9 6	31	10 0	29	3 8	9	3 6	8	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
Average	33.0	102	9.5	39	7.4	23	7.1	20	4.9	12	3.0	7	1.2	2	0	0	0	0	0	0	0	0	4.4	....
Cull fruits—																								
1912	10 15	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00	....
1913	3 11	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.33	....
1914	2 2	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
1915	2 2	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.33	....
Average	4.7	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.83	....
Total crop—																								
1912	197 12	561	27 6	99	47 8	148	38 7	106	50 6	126	16 8	36	6 10	13	0 0	0	0 0	0	0 0	0	0 0	0	3.56	1
1913	140 8	466	42 4	177	36 3	113	19 11	55	26 13	68	6 15	16	3 2	6	0 0	0	1 13	3	0 0	0	0 0	0	5.33	2
1914	126 4	386	62 10	212	34 11	97	16 0	40	9 6	21	1 7	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	7
1915	153 7	430	6 3	25	24 12	81	41 5	120	51 6	134	20 7	47	5 12	12	1 8	3	0 0	0	0 0	0	0 0	0	5.00	6
Average	**154.5**	**461**	**34.6**	**128**	**35.8**	**110**	**28.9**	**80**	**34.5**	**87**	**11.3**	**26**	**3.9**	**8**	**0.4**	**1**	**0.5**	**1**	**0**	**0**	**0**	**0**	**4.56**	**4**
15, tree No. 23-90 9, Valencia strain:																								
Orchard grade—																								
1912	110 12	274	2 15	11	10 4	32	14 5	40	36 6	92	22 8	51	18 11	38	2 10	5	2 6	4	0 11	1	0 0	0	1.00	....
1913	93 14	313	37 0	146	27 8	88	15 13	45	11 5	29	2 4	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	138 7	411	62 12	209	44 3	125	24 8	61	6 7	15	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	120 1	407	36 0	140	48 9	163	19 0	58	16 8	46	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	7.00	....
Average	115.8	351	34.7	125	32.6	102	18.4	51	17.7	46	6.3	14	4.7	10	0.7	1	0.6	1	0.2	0.3	0	0	3.33	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
16, tree No. 23–93–9, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	122 2	215	0 4	1	1 2	3	2 6	6	6 1	14	9 12	20	25 0	47	5 11	10	38 4	62	15 6	22	0 0	0	0.22	0
1913	124 10	453	37 11	160	29 7	95	20 10	61	20 15	53	7 9	17	2 13	6	0 9	1	0 10	1	0 0	0	0 0	0	4.00	1
1914	180 11	542	73 9	251	60 10	171	30 5	76	11 10	27	2 8	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.44	8
1915	185 5	527	7 5	30	43 8	140	50 6	144	58 2	149	17 7	39	5 12	12	1 2	2	0 0	0	0 0	0	0 0	0	4.33	7
Average	**153.2**	**434**	**29.7**	**111**	**33.7**	**102**	**25.9**	**72**	**24.2**	**61**	**9.3**	**20**	**8.4**	**16**	**1.8**	**1**	**9.7**	**16**	**3.8**	**6**	**0**	**0**	**3.00**	**4**
17, tree No. 23–88–10, Valencia strain:																								
Orchard grade—																								
1912	78 2	152	0 0	0	0 15	3	2 9	7	6 12	16	15 15	35	22 0	43	5 14	10	13 12	23	10 5	15	0 0	0	1.00	....
1913	109 10	339	22 6	91	34 4	110	22 8	64	23 12	60	3 9	8	2 9	5	0 10	1	0 0	0	0 0	0	0 0	0	4.33	....
1914	118 10	313	21 7	67	43 6	118	38 5	94	13 0	29	2 8	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	135 8	354	2 6	9	8 6	27	29 5	85	56 6	146	26 13	62	10 2	21	1 8	3	0 10	1	0 0	0	0 0	0	5.33	....
Average	110.5	290	11.5	42	21.7	65	23.2	63	25.0	63	12.2	28	8.7	17	2.0	4	3.6	6	2.6	4	0 0	0	3.25	....
Standard grade—																								
1912	49 4	103	0 4	1	2 2	6	5 10	15	8 7	20	8 9	18	13 3	24	2 4	4	8 13	15	0 0	0	0 0	0	1.33	....
1913	27 8	118	18 12	90	6 14	23	1 7	4	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.00	....
1914	25 2	73	7 6	25	8 2	24	4 15	13	3 4	8	0 15	2	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1915	43 7	130	2 12	12	14 8	47	15 4	44	9 3	23	1 12	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	7.00	....
Average	36.3	106	7.3	32	7.9	25	6.8	19	5.3	13	2.8	6	3.4	6	0.6	1	2.2	4	0	0	0	0	4.83	....
Cull fruits—																								
1912	4 8	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
1913	4 10	63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
1914	3 8	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
1915	4 8	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.67	....
Average	4.3	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.84	....

Total crop—																														
1912	131	14	266	0	4	1	3	1	9	8	3	22	15	3	36	24	8	53	35	3	67	8	2	14	22	9	38	10	5	15	0	0	0	1.89	0
1913	141	12	520	41	2	181	41	2	133	23	15	68	24	3	61	3	9	8	2	9	5	0	10	1	0	0	0	0	0	0	0	0	0	4.67	0
1914	147	4	403	28	13	92	51	8	142	43	4	107	16	4	37	3	7	7	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.67	12
1915	183	7	501	5	2	21	22	14	74	44	9	129	65	9	169	28	9	66	10	2	21	1	8	3	0	10	1	0	0	0	0	0	0	5.67	15
Average	**151.1**		**423**	**18.8**		**74**	**29.6**		**90**	**29.7**		**82**	**30.3**		**76**	**15.0**		**34**	**12.1**		**24**	**2.6**		**5**	**5.8**		**10**	**2.6**		**4**	**0**		**0**	**3.98**	**7**
18, tree No. 23-85-3, Valencia strain:																																			
Orchard grade—																																			
1912	127	3	290	1	11	6	10	13	33	10	14	30	27	2	67	26	5	58	40	11	80	3	6	6	4	4	7	2	1	3	0	0	0	.33	....
1913	101	5	361	43	5	180	39	9	131	9	10	28	6	1	16	2	3	5	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	88	0	213	8	2	28	20	8	54	30	9	71	23	0	49	5	5	10	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	114	13	327	2	0	8	10	5	37	25	9	80	59	8	162	14	9	34	2	14	6	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
Average	107.8		298	13.8		56	20.3		64	19.2		52	28.9		74	12.1		27	11.2		22	0.8		2	1.1		2	0.5		1	0		0	3.00	....
Standard grade—																																			
1912	29	5	69	2	15	11	1	10	5	3	12	10	4	10	11	6	3	13	8	5	16	0	0	0	1	14	3	0	0	0	0	0	0	1.33	....
1913	21	7	100	13	11	71	7	1	27	0	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1914	18	15	53	4	13	19	6	2	17	2	7	6	2	12	6	1	8	3	1	5	2	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	67	3	225	25	1	97	24	14	81	11	10	33	4	11	12	0	7	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	6.33	....
Average	34.2		112	11.6		50	9.9		33	4.6		13	3.0		7	2.0		4	2.5		5	0		0	0.5		1	0		0	0		0	3.92	....
Cull fruits—																																			
1912	15	5	32																															1.00	....
1913	8	3	100																															2.50	....
1914	2	6	9																															4.33	....
1915	2	13	18																															5.33	....
Average	7.2		40																															3.29	....
Total crop—																																			
1912	171	13	391	4	10	17	12	7	38	14	10	40	31	12	78	32	8	71	49	0	96	3	6	6	6	2	10	2	1	3	0	0	0	.89	4
1913	130	15	561	57	0	251	46	10	158	10	5	30	6	1	16	2	3	5	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	3.13	4
1914	109	5	275	12	15	47	26	10	71	33	0	77	25	12	55	6	13	13	1	13	3	0	0	0	0	0	0	0	0	0	0	0	0	3.89	12
1915	184	13	570	27	1	105	35	3	118	37	3	113	64	3	174	15	0	35	3	6	7	0	0	0	0	0	0	0	0	0	0	0	0	5.78	6
Average	**149.2**		**449**	**25.3**		**105**	**30.2**		**96**	**23.8**		**66**	**31.9**		**81**	**14.1**		**31**	**13.7**		**27**	**0.8**		**2**	**1.5**		**3**	**0.5**		**1**	**0**		**0**	**3.42**	**7**
19, tree No. 23-87-8, Valencia strain:																																			
Orchard grade—																																			
1912	77	0	200	1	12	6	4	2	13	9	0	26	20	10	52	18	12	42	9	10	39	5	10	10	4	11	8	2	13	4	0	0	0	1.00	....
1913	92	0	313	29	6	126	30	15	100	17	11	51	11	14	31	2	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1914	129	6	405	80	10	273	33	10	95	13	6	33	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
1915	157	10	496	28	10	107	48	14	162	38	8	115	38	4	104	3	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
Average	114.0		354	35.1		128	29.4		93	19.6		56	18.1		48	6.1		14	2.4		10	1.4		3	1.2		2	0.7		1	0		0	2.67	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
19, tree No. 23-87-8, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	54 2	114	1 14	7	1 11	5	3 0	8	5 14	11	10 9	23	18 15	36	2 14	5	9 5	16	0 0	0	0 0	0	2.33	....
1913	27 2	127	21 14	109	4 4	15	1 0	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1914	13 15	50	9 8	38	2 11	8	0 12	2	0 0	0	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	31 10	112	12 3	50	13 2	45	4 6	12	1 8	4	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	8.00	....
Average	31.7	101	11.1	51	5.1	18	2.3	6	1.8	5	3.0	7	4.7	9	0.7	1	2.3	4	0	0	0	0	4.50	....
Cull fruits—																								
1912	1 8	4																					1.67	....
1913	4 14	59																					5.00	....
1914	4 8	23																					5.67	....
1915	2 13	12																					3.00	....
Average	3.4	25																					3.84	....
Total crop—																								
1912	132 10	318	3 10	13	5 13	18	12 0	34	26 8	66	29 5	65	28 9	75	8 8	15	14 0	24	2 13	4	0 0	0	1.67	1
1913	124 0	499	51 4	235	35 3	115	18 11	54	11 14	31	2 2	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.89	3
1914	147 13	478	90 2	311	36 5	103	14 2	35	1 12	4	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.22	8
1915	192 1	620	40 13	157	62 0	207	42 14	127	39 12	108	3 13	9	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.89	17
Average	**149.1**	**479**	**46.5**	**179**	**34.8**	**111**	**21.9**	**63**	**20.0**	**52**	**9.1**	**20**	**7.1**	**19**	**2.1**	**4**	**3.5**	**6**	**0.7**	**1**	**0**	**0**	3.67	**7**
20, tree No. 23-87-5, Valencia strain:																								
Orchard grade—																								
1912	108 12	257	2 3	8	9 4	28	9 2	25	36 14	90	25 11	57	19 1	38	2 5	4	4 4	7	0 0	0	0 0	0	1.67	....
1913	88 3	252	17 13	70	19 14	63	12 4	33	21 7	52	10 0	22	5 7	10	0 0	0	1 6	2	0 0	0	0 0	0	1.00	....
1914	133 3	381	49 4	161	48 1	134	22 4	56	12 11	28	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1915	105 12	274	2 11	9	5 2	16	14 14	42	50 2	125	20 6	45	11 6	23	2 3	4	0 0	0	0 0	0	0 0	0	3.67	....
Average	109.2	289	18.0	62	20.6	60	14.6	39	30.3	74	14.3	32	9.0	18	1.1	2	1.5	2	0	0	0	0	2.67	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
21, tree No. 23-85-4, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	109 0	221	0 14	3	2 1	6	2 10	7	16 6	38	19 7	41	27 6	52	7 0	12	11 8	19	1 7	2	0 0	0	0.56	14
1913	126 15	526	57 8	254	36 1	119	14 6	42	11 14	31	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.13	14
1914	154 11	420	51 15	169	36 2	97	30 3	94	18 7	40	6 7	13	1 1	2	0 9	1	0 0	0	0 0	0	0 0	0	3.00	29
1915	201 13	615	28 5	111	44 2	144	49 9	149	58 14	157	15 9	37	2 12	6	0 0	0	0 0	0	0 0	0	0 0	0	3.67	45
Average	**148.1**	**446**	**34.7**	**134**	**29.6**	**92**	**26.4**	**73**	**26.4**	**67**	**10.6**	**23**	**7.8**	**16**	**1.9**	**3**	**2.9**	**5**	**0.4**	**0.5**	**0**	**0**	**2.59**	**26**
22, tree No. 23-92-1, Valencia strain:																								
Orchard grade—																								
1912	74 5	167	0 13	3	2 6	8	5 5	15	13 10	34	16 2	36	25 7	51	2 10	6	6 2	11	1 14	3	0 0	0	.33	....
1913	78 3	255	22 10	90	25 11	86	11 8	33	10 15	29	6 0	14	1 7	3	0 0	0	0 0	0	0 0	0	0 0	0	1.00	....
1914	130 5	370	65 1	193	37 8	108	17 13	46	8 15	21	0 0	0	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	68 4	177	0 10	3	4 5	13	15 0	44	25 10	67	11 5	27	9 8	20	1 14	3	0 0	0	0 0	0	0 0	0	3.33	....
Average	87.8	242	22.1	72	17.5	54	12.4	35	14.8	38	8.4	19	9.3	19	1.1	2	1.5	3	0.5	1	0	0	1.75	....
Standard grade—																								
1912	77 13	173	1 6	5	3 7	11	4 1	11	21 7	52	16 4	35	20 7	40	2 3	4	8 10	15	0 0	0	0 0	0	1.00	....
1913	46 15	194	32 6	150	7 6	24	4 0	12	3 3	8	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1914	30 9	106	16 10	67	5 11	18	4 0	11	2 0	5	1 11	4	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	37 13	108	2 2	9	8 6	28	10 13	32	8 0	21	4 13	11	3 11	7	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
Average	48.3	145	13.1	58	6.2	20	5.7	17	8.7	22	5.7	13	6.2	12	0.5	1	2.2	4	0	0	0	0	2.58	....
Cull fruits—																								
1912	28 4	59																					0	....
1913	2 11	33																					.33	....
1914	2 5	11																					2.67	....
1915	14 6	8																					1.67	....
Average	11.9	28																					1.17	....

Total crop—																														
1912	180	6	399	2	3	8	5	13	19	9	6	26	35	1	86	32	6	71	45	14	91	4	13	10	14	12	26	1	14	3	0	0	0	.44	20
1913	127	13	482	55	0	240	33	1	110	15	8	45	14	2	37	6	0	14	1	7	3	0	0	0	0	0	0	0	0	0	0	0	0	1.22	16
1914	163	3	487	81	11	260	43	3	126	21	13	57	10	15	26	1	11	4	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	2.89	52
1915	120	7	293	2	12	12	12	11	41	25	13	76	33	10	88	16	2	38	13	3	27	1	14	3	0	0	0	0	0	0	0	0	0	2.78	21
Average	**148.0**		**415**	**35**	**4**	**130**	**23.7**		**74**	**18.1**		**51**	**23.4**		**59**	**14.0**		**32**	**15.5**		**31**	**1.7**		**3**	**3.7**		**7**	**0.5**		**1**	**0**		**0**	**1.83**	**27**
23, tree No. 23-75-19, Valencia strain:																																			
Orchard grade—																																			
1912	87	2	182	0	4	1	2	15	9	2	15	8	13	4	32	15	11	34	32	7	64	6	12	12	11	10	20	1	4	2	0	0	0	.33	....
1913	107	10	340	27	5	103	40	8	129	22	10	65	14	15	38	2	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	106	0	288	20	12	67	37	4	103	35	6	90	10	11	24	1	7	3	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	125	1	317	2	0	7	6	8	20	19	8	56	56	8	144	25	5	58	11	10	25	3	10	7	0	0	0	0	0	0	0	0	0	7.67	....
Average	106.5		282	12.6		45	21.8		65	19.6		55	23.3		60	11.2		25	11.1		23	2.6		5	2.9		5	0.1		0.5	0		0	3.83	....
Standard grade—																																			
1912	49	4	103	0	12	3	1	10	5	2	15	8	6	14	16	9	5	20	17	5	33	1	10	3	8	13	15	0	0	0	0	0	0	.67	....
1913	37	8	157	27	0	122	8	4	28	1	9	5	0	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
1914	9	11	29	1	14	8	3	1	9	2	8	7	1	11	4	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1915	27	5	79	1	4	7	6	0	19	8	12	25	6	9	17	4	4	10	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	7.33	....
Average	30.9		92	7.7		35	4.7		15	3.9		11	4.0		10	3.5		8	4.5		9	0.2		1	2.2		4	0		0	0		0	4.75	....
Cull fruits—																																			
1912	23	8	49																															1.33	....
1913	4	10	55																															4.33	....
1914	4	10	21																															2.00	....
1915	1	7	6																															7.33	....
Average	8.5		33																															3.75	....
Total crop—																																			
1912	159	14	334	1	0	4	4	9	14	5	14	16	20	2	48	25	0	54	49	12	97	8	6	15	20	7	35	1	4	2	0	0	0	.78	0
1913	149	12	552	54	5	225	48	12	157	24	3	70	15	10	40	2	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.11	3
1914	120	15	338	22	10	75	40	5	112	37	14	97	12	6	28	2	0	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	4.11	3
1915	153	13	402	3	4	14	12	8	39	28	4	81	63	1	161	29	9	68	12	2	26	3	10	7	0	0	0	0	0	0	0	0	0	8.11	7
Average	**146.3**		**407**	**20.3**		**80**	**26.5**		**81**	**24.0**		**66**	**27.8**		**69**	**14.7**		**33**	**15.8**		**31**	**3.0**		**6**	**5.1**		**9**	**0.3**		**0.5**	**0**		**0**	**4.28**	**3**
24, tree No. 23-86-6, Valencia strain:																																			
Orchard grade—																																			
1912	56	13	112	0	4	1	0	5	1	0	12	2	10	14	26	13	14	29	13	12	26	5	6	9	8	2	13	3	8	5	0	0	0	.33	....
1913	106	1	367	46	3	186	37	2	120	12	0	34	9	7	24	1	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	97	7	237	10	12	33	25	10	68	34	8	82	17	8	37	8	9	16	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	151	6	431	4	8	18	18	0	63	44	9	133	62	8	166	18	8	43	3	5	7	0	9	1	0	0	0	0	0	0	0	0	0	4.33	....
Average	102.9		287	15.4		60	20.3		63	22.8		63	25.1		63	10.6		23	4.4		9	1.5		3	2.0		3	0	9	1	0		0	3.00	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
24, tree No. 23-86-6, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	51 15	104	0 9	2	0 11	2	4 10	12	11 7	26	8 12	18	14 8	26	2 6	4	9 0	14	0 0	0	0 0	0	0.33	....
1913	35 7	160	28 0	137	4 12	16	1 12	5	0 6	1	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1914	18 3	52	5 3	19	4 14	14	2 12	7	3 7	8	1 7	3	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	44 4	139	15 2	57	10 8	33	10 1	28	5 11	14	2 6	6	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
Average	37.5	114	12.2	54	5 2	16	4.8	13	5.2	12	3.3	7	3.9	7	0.6	1	2.3	4	0	0	0	0	2.25	....
Cull fruits—																								
1912	9 7	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	....
1913	5 5	54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.33	....
1914	1 14	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.33	....
1915	3 6	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
Average	5 0	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.50	....
Total crop—																								
1912	118 3	233	0 13	3	1 0	3	5 6	14	22 5	52	22 10	47	28 4	52	7 12	13	17 2	27	3 8	5	0 0	0	.56	9
1913	146 13	581	74 3	323	41 14	136	13 12	39	9 13	25	1 14	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	9
1914	117 8	301	15 15	52	30 8	82	37 4	89	20 15	45	10 0	19	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	4.22	17
1915	199 0	583	19 10	75	28 8	96	54 1	161	68 3	180	20 14	49	3 13	8	0 9	1	0 0	0	0 0	0	0 0	0	3.22	31
Average	145.4	425	27.6	113	25.5	79	27.6	76	30.3	76	13.8	30	8.3	16	2.1	4	4.3	7	0.9	1	0	0	2.92	17
25, tree No. 23-87-9, Valencia strain:																								
Orchard grade—																								
1912	77 14	173	1 0	4	4 3	13	5 8	15	16 14	42	17 6	38	21 3	42	4 11	8	3 10	6	3 7	5	0 0	0	0	....
1913	99 9	348	41 12	177	28 4	93	12 8	36	12 5	32	3 10	8	0 8	1	0 0	0	0 10	1	0 0	0	0 0	0	2.00	....
1914	93 3	242	21 0	66	28 1	75	28 12	69	11 10	25	3 12	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	140 4	406	12 4	46	27 7	90	33 4	97	52 11	140	10 5	24	4 5	9	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
Average	102.7	292	19.0	73	22.0	68	20.0	54	23.4	60	8.8	19	6.5	13	1.2	2	1.1	2	0.9	1	0	0	2.75	....

Standard grade—																																			
1912	44	15	95	0	4	1	4	6	13	1	14	5	7	3	17	9	9	20	13	2	25	0	9	1	8	0	13	0	0	0	0	0	0	.67	....
1913	34	14	151	23	13	115	6	12	24	2	9	8	1	4	3	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
1914	25	15	67	4	8	17	4	8	13	3	8	9	5	2	12	3	6	7	3	13	7	0	9	1	0	9	1	0	0	0	0	0	0	2.33	....
1915	42	5	133	9	6	36	11	11	38	14	11	43	4	1	10	2	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
Average	37.0		112	9.5		42	6.8		22	5.7		16	4.4		11	4.1		9	4.2		8	0.3		0.5	2.1		4	0		0	0	0	2.75	....
Cull fruits—																																			
1912	13	3	20																															0	....
1913	5	5	58																															2.33	....
1914	0	14	5																															3.00	....
1915	1	12	6																															3.00	....
Average	5.3		22																															2.08	....
Total crop—																																			
1912	136	0	288	1	4	5	8	9	26	7	6	20	21	1	59	26	15	58	34	5	67	5	4	9	11	10	19	3	7	5	0	0	0	.22	20
1913	139	12	557	65	9	292	35	0	117	15	1	44	13	9	35	4	2	9	0	8	1	0	0	0	0	10	1	0	0	0	0	0	0	2.56	15
1914	120	0	314	25	8	83	32	9	88	32	4	78	16	12	37	7	2	14	3	13	7	0	9	1	0	9	1	0	0	0	0	0	0	3.00	43
1915	184	5	545	21	10	82	39	2	128	47	15	140	56	12	150	12	13	30	4	5	9	0	0	0	0	0	0	0	0	0	0	0	0	4.33	47
Average	**145.0**		**426**	**28.5**		**116**	**29.0**		**90**	**25.7**		**71**	**27.7**		**70**	**12.8**		**28**	**10.7**		**21**	**1.5**		**3**	**3.2**		**5**	**0.9**		**1**	**0**	**0**	**2.53**	**31**
26, tree No. 23-88-2, Valencia strain:																																			
Orchard grade																																			
1912	82	13	214	5	13	22	12	14	39	14	6	39	24	6	60	16	0	35	9	6	19	0	0	0	0	0	0	0	0	0	0	0	0	2.00	....
1913	75	6	261	34	1	138	25	15	82	8	3	23	6	5	16	0	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1914	130	11	417	79	7	277	37	9	106	11	14	30	1	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1915	92	3	256	2	14	11	16	6	52	23	2	66	38	8	101	9	1	21	2	4	5	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
Average	95.0		287	30.5		112	23.2		70	14.4		40	17.8		45	6.5		15	2.9		6	0		0	0		0	0		0	0	0	3.42	....
Standard grade—																																			
1912	64	0	159	4	4	18	6	10	20	13	5	36	19	3	45	7	12	16	9	15	19	0	9	1	2	6	4	0	0	0	0	0	0	.67	....
1913	29	11	131	24	9	115	3	2	11	1	0	3	0	8	1	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
1914	16	0	58	8	15	37	4	11	15	0	11	2	0	13	2	0	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1915	68	10	209	6	7	26	25	0	83	19	6	56	12	9	32	4	13	11	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
Average	44.6		139	11.0		49	9.9		32	8.6		24	8.3		20	3.4		7	2.7		5	0.1		0.3	0.6		1	0		0	0	0	2.42	....
Cull fruits—																																			
1912	10	9	32																															0	....
1913	4	5	46																															3.33	....
1914	1	12	11																															3.00	....
1915	3	14	15																															3.67	....
Average	5.1		26																															2.50	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
26, tree No. 23-88-2, Valencia strain—Continued.																								
Total crop—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	157 6	405	10 1	40	19 8	59	27 11	75	43 9	105	23 12	51	19 5	38	0 9	1	2 6	4	0 0	0	0 0	0	0.89	3
1913	109 6	438	58 10	253	29 1	93	9 3	26	6 13	17	0 14	2	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.78	3
1914	148 7	486	88 6	314	42 4	121	12 9	32	2 10	6	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.56	31
1915	164 11	480	9 5	37	41 6	135	42 8	122	51 1	133	13 11	32	2 11	6	0 0	0	0 0	0	0 0	0	0 0	0	3.56	39
Average	**145.0**	**452**	**41.6**	**161**	**33.1**	**102**	**23.0**	**64**	**26.0**	**65**	**10.0**	**22**	**5.6**	**11**	**0.1**	**0.3**	**0.6**	**1**	**0**	**0**	**0**	**0**	**2.70**	**19**
27, tree No. 23-85-6, Valencia strain:																								
Orchard grade—																								
1912	68 3	145	0 3	1	3 3	10	3 9	10	14 12	36	12 8	27	16 13	33	3 14	7	9 2	15	4 3	6	0 0	0	2.00	....
1913	94 2	321	35 6	146	31 9	103	13 7	38	12 6	31	1 6	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1914	94 8	229	10 10	33	24 6	65	22 6	54	24 5	52	12 5	24	0 8	1	0 6	0	0 0	0	0 0	0	0 0	0	5.67	....
1915	104 3	293	1 11	7	5 9	20	25 11	81	52 0	141	13 9	32	4 11	10	1 0	2	0 0	0	0 0	0	0 0	0	5.00	....
Average	90.3	247	12.0	47	16.2	50	16.3	46	25.9	65	9.9	22	5.5	11	1.2	2	2.3	4	1.1	2	0	0	3.75	....
Standard grade—																								
1912	31 13	74	1 13	6	1 6	4	4 9	12	9 9	23	6 1	13	6 9	13	0 0	0	1 14	3	0 0	0	0 0	0	1.00	....
1913	22 7	99	16 10	82	2 9	9	1 13	5	0 15	2	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.33	....
1914	36 1	94	7 1	25	10 2	28	5 0	13	5 5	12	3 9	7	4 6	8	0 0	0	0 10	1	0 0	0	0 0	0	4.33	....
1915	90 11	278	16 8	63	33 11	107	23 14	67	11 6	29	4 10	11	0 0	0	0 10	1	0 0	0	0 0	0	0 0	0	5.00	....
Average	45.3	136	10.5	44	11.4	37	8.8	24	6.8	17	3.7	8	2.7	5	0.2	0.3	0.6	1	0	0	0	0	2.92	....
Cull fruits—																								
1912	16 2	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	8 6	81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1914	2 2	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....
1915	2 5	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.67	....
Average	7.2	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.42	....

Total crop—																														
1912	116	2	252	2	0	7	4	9	14	8	2	22	24	5	59	18	9	40	23	6	46	3	14	7	11	0	18	4	3	6	0	0	0	1.00	23
1913	124	15	501	52	0	228	34	2	112	15	4	43	13	5	33	1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.78	14
1914	132	11	333	17	11	58	34	8	93	27	6	67	29	10	64	15	14	31	4	14	9	0	0	0	0	10	1	0	0	0	0	0	0	4.11	42
1915	197	3	581	18	3	70	39	4	127	49	9	148	63	6	170	18	3	43	4	11	10	1	10	3	0	0	0	0	0	0	0	0	0	5.22	68
Average	142.7		417	22.5		91	28.1		87	25.1		70	32.7		82	13.6		30	8.2		16	1.4		3	2.9		5	1.1		2	0		0	3.03	38
28, tree No. 23-75-24, Sporting strain:																																			
Orchard grade—																																			
1912	133	2	324	4	4	17	17	8	53	16	0	44	39	13	98	21	15	48	25	8	50	2	14	5	5	4	9	0	0	0	0	0	0	2.00	....
1913	104	6	346	42	6	164	36	7	114	17	9	48	7	1	18	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1914	89	2	263	42	14	143	24	4	68	12	15	32	8	2	18	0	7	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
1915	85	8	227	1	11	6	11	13	36	21	6	61	37	2	94	10	1	23	2	14	6	0	9	1	0	0	0	0	0	0	0	0	0	6.00	....
Average	103.0		290	22.8		83	22.5		68	17.0		46	23.0		57	8.3		19	7.2		14	0.9		2	1.3		2	0		0	0		0	4.17	....
Standard grade—																																			
1912	19	11	47	1	5	5	2	0	6	2	15	8	5	1	12	3	6	7	3	13	7	0	9	1	0	10	1	0	0	0	0	0	0	2.33	....
1913	31	10	136	26	6	120	3	13	12	1	1	3	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1914	24	1	80	12	6	48	6	4	19	1	8	4	3	8	8	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1915	60	0	176	6	8	27	13	0	43	20	5	58	11	11	30	4	14	11	2	8	5	1	2	2	0	0	0	0	0	0	0	0	0	6.00	....
Average	33.8		110	11.6		50	6.3		20	6.5		18	5.2		13	2.2		5	1.6		3	0.4		1	0.2		0.3	0		0	0		0	4.00	....
Cull fruits—																																			
1912	12	0	30																															1.33	....
1913	4	6	66																															5.33	....
1914	1	0	6																															3.33	....
1915	2	5	22																															5.33	....
Average	4.9		31																															3.83	....
Total crop—																																			
1912	164	13	401	5	9	22	19	8	59	18	15	52	44	14	110	25	5	55	29	5	57	3	7	6	5	14	10	0	0	0	0	0	0	1.89	14
1913	140	6	548	68	12	284	40	4	126	18	10	51	7	7	19	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.56	22
1914	114	3	349	55	4	191	30	8	87	14	7	36	11	10	26	0	14	2	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.78	39
1915	147	13	425	8	3	33	24	13	79	41	11	119	48	13	124	14	15	34	5	6	11	1	11	3	0	0	0	0	0	0	0	0	0	5.77	63
Average	141.8		431	34.4		133	28.8		88	23.4		65	28.2		70	10.5		23	8.8		17	1.3		2	1.5		3	0		0	0		0	4.00	35
29, tree No. 23-75-22, Valencia strain:																																			
Orchard grade—																																			
1912	65	12	162	1	12	7	9	9	30	6	12	19	21	6	53	9	2	20	12	7	25	2	4	4	2	8	4	0	0	0	0	0	0	2.33	....
1913	111	11	383	46	12	187	38	10	125	13	12	39	10	4	27	1	13	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1914	79	9	233	30	10	104	25	11	72	14	2	36	8	3	19	0	7	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1915	101	6	260	0	4	1	6	8	20	19	8	56	49	10	126	16	6	38	7	8	16	1	10	3	0	0	0	0	0	0	0	0	0	4.33	....
Average	89.6		260	19.8		75	20.1		62	13.5		38	22.4		56	6.9		16	5.2		11	0.9		2	0.6		1	0		0	0		0	3.67	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
29, tree No. 23-75-22, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	60 3	157	8 13	33	9 0	27	8 0	22	14 15	37	7 0	15	8 3	16	1 2	2	3 2	5	0 0	0	0 0	0	4.67	....
1913	23 12	105	18 14	89	4 3	14	0 11	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
1914	30 10	98	13 12	53	6 9	20	2 9	7	5 4	13	2 0	4	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	68 10	185	2 0	9	10 10	36	14 0	41	20 15	54	13 6	31	4 1	8	2 6	4	1 4	2	0 0	0	0 0	0	5.33	....
Average	45.8	136	10.9	46	7.6	24	6.3	18	10.3	26	5.6	13	3.2	6	1.1	2	1.1	2	0	0	0	0	4.67	....
Cull fruits—																								
1912	11 7	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
1913	4 13	62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
1914	1 2	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00	....
1915	3 2	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
Average	5.1	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.17	....
Total crop—																								
1912	137 6	348	10 9	40	18 9	57	14 12	41	36 5	90	16 2	35	20 10	41	3 6	6	5 10	9	0 0	0	0 0	0	3.22	2
1913	140 4	550	65 10	276	42 13	139	14 7	41	10 4	27	1 13	4	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.22	11
1914	111 5	338	44 6	157	32 4	92	16 11	43	13 7	32	2 7	5	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	3.56	27
1915	173 2	459	2 4	10	17 2	56	33 8	97	70 9	180	29 12	69	11 9	24	4 0	7	1 4	2	0 0	0	0 0	0	4.33	44
Average	**140.5**	**424**	**30.7**	**121**	**27.7**	**86**	**19.8**	**56**	**32.6**	**82**	**12.5**	**28**	**8.4**	**17**	**1.8**	**3**	**1.7**	**3**	**0**	**0**	**0**	**0**	3.83	**21**
30, tree No. 23-91-2, Valencia strain:																								
Orchard grade—																								
1912	60 0	122	1 0	4	2 5	7	1 10	4	8 5	20	6 0	13	26 2	50	2 14	5	8 4	14	3 8	5	0 0	0	0	....
1913	80 10	292	45 11	186	21 12	70	6 14	20	5 14	15	0 0	0	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	103 15	312	46 6	160	34 10	97	13 2	33	7 15	18	1 14	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	96 8	305	22 6	82	31 8	103	21 6	64	18 4	49	3 0	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.00	....
Average	85.3	258	28.9	108	22.6	69	10.8	30	10.1	26	2.7	6	6.6	13	0.7	1	2.1	4	0.9	1	0	0	3.17	....

Standard grade—																																			
1912	38	8	83	0	8	2	1	12	5	2	4	6	10	10	25	8	1	17	10	0	19	2	3	4	3	2	5	0	0	0	0	0	0	0	....
1913	27	12	128	23	0	113	4	6	14	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.00	....
1914	40	3	136	21	4	85	8	7	25	4	14	13	3	12	9	1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	66	1	226	20	5	86	23	9	79	13	0	38	6	9	17	2	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.00	....
Average	43.1		143	16.3		72	9.5		31	5.1		15	5.2		13	3.1		7	2.5		5	0.5		1	0.8		1	0		0	0		0	3.25	....
Cull fruits—																																		
1912	33	10	68																														.33	....
1913	6	13	88																														1.67	....
1914	2	11	19																														1.67	....
1915	3	1	26																														4.00	....
Average	11.5		50																														1.92	....
Total crop—																																		
1912	132	2	273	1	8	6	4	1	12	3	14	10	18	15	45	14	1	30	36	2	69	5	1	9	11	6	19	3	8	5	0	0	0	.11	8
1913	115	3	508	68	11	299	26	2	84	7	4	21	5	14	15	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	2.22	4
1914	146	13	467	67	10	245	43	1	122	18	0	46	11	11	27	3	12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.11	56
1915	165	10	557	42	11	168	55	1	182	34	6	102	24	13	66	5	10	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.67	48
Average	139.9		451	45.1		180	32.1		100	15.9		45	15.3		38	5.9		13	9.1		18	1.3		2	2.8		5	0.9		1	0		0	2.78	29
31, tree No. 23-93-5, Valencia strain:																																		
Orchard grade—																																		
1912	107	3	236	0	12	3	3	9	11	4	9	13	29	0	71	25	2	55	30	5	59	5	11	10	8	3	14	0	0	0	0	0	0	.67	....
1913	80	15	250	17	8	70	25	13	83	11	4	32	17	8	45	7	14	18	1	0	2	0	0	6	0	0	0	0	0	0	0	0	0	2.00	....
1914	117	3	327	33	6	110	37	11	105	32	14	82	11	14	27	1	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	104	12	274	3	6	11	10	8	32	23	14	68	43	7	111	19	9	44	4	0	8	0	0	0	0	0	0	0	0	0	0	0	0	6.00	....
Average	102.5		272	13.8		49	19.4		58	18.1		49	25.5		64	13.5		30	8.8		17	1.4		3	2.1		4	0		0	0		0	3.17	....
Standard grade—																																		
1912	43	0	96	1	2	4	2	15	9	2	7	25	10	7	25	10	0	21	12	11	24	0	0	0	3	6	6	0	0	0	0	0	0	2.33	....
1913	29	13	127	22	15	105	5	12	19	0	11	2	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1914	20	14	66	8	6	32	5	10	17	1	14	5	5	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	33	5	103	5	8	22	12	14	42	7	9	21	4	10	12	2	12	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.33	....
Average	31.8		98	9.6		41	6.8		22	3.1		9	5.1		13	3.2		7	3.2		6	0		0	0.8		2	0		0	0		0	3.92	....
Cull fruits—																																		
1912	16	9	40																														.67	....
1913	2	12	45																														6.33	....
1914	2	4	14																														2.00	....
1915	0	6	5																														2.33	....
Average	5.5		26																														2.83	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
31, tree No. 23-93-5, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*					
1912	166 12	372	1 14	7	6 8	20	7 0	20	39 7	96	35 2	76	43 0	83	5 11	10	11 9	2	0 0	0	0 0	0	1.22	2
1913	113 8	422	40 7	175	31 9	102	11 15	34	17 15	46	7 14	18	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	3.78	1
1914	140 5	407	41 12	142	43 5	122	34 12	87	16 14	39	1 6	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	5
1915	138 7	382	8 14	33	23 6	74	31 7	89	48 1	123	22 5	50	4 0	8	0 0	0	0 0	0	0 0	0	0 0	0	4.89	2
Average	139.8	396	23.2	89	26.2	79	21.3	58	30.6	76	16.7	37	12.0	23	1.4	3	2.9	5	0	0	0	0	3.31	3
32, tree No. 23-85-10, Valencia strain:																								
Orchard grade—																								
1912	91 5	204	0 15	3	6 9	19	5 14	16	26 15	65	18 15	41	23 10	46	2 11	5	3 0	5	2 0	3	0 12	1	.67	....
1913	96 9	295	23 6	101	20 5	67	12 8	36	20 11	52	8 5	18	7 3	11	2 15	5	1 4	2	0 0	0	0 0	0	3.67	....
1914	111 4	302	30 2	96	36 15	102	25 2	62	16 1	36	3 0	6	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1915	119 11	319	1 10	6	5 14	20	18 12	57	58 5	155	25 1	59	9 9	21	0 8	1	0 0	0	0 0	0	0 0	0	3.33	....
Average	104.7	280	14.0	52	17.4	52	15.6	43	30.5	77	13.8	31	10.1	20	1.5	3	1.1	2	0.5	1	0.2	0.3	3.09	....
Standard grade—																								
1912	19 1	46	4 5	14	1 10	5	2 5	6	3 10	8	1 15	4	2 4	4	1 12	3	1 4	2	0 0	0	0 0	0	1.67	....
1913	19 1	77	12 11	60	1 12	6	2 4	6	0 14	2	1 0	2	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1914	16 11	53	5 15	23	7 11	22	1 13	5	1 4	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	64 15	195	10 10	41	21 0	75	13 2	37	13 1	33	2 10	6	1 8	3	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
Average	29.9	93	8.4	35	8.8	27	4.9	14	4.7	12	1.4	3	1.1	2	0.2	1	0.1	0.5	0	0	0	0	3.84	....
Culls fruits—																								
1912	7 0	17																					1.67	....
1913	7 9	78																					4.33	....
1914	2 8	13																					4.33	....
1915	0 12	4																					1.67	....
Average	4.5	28																					3.00	....

Total crop—																														
1912	117	6	267	5	4	17	8	3	24	8	3	22	30	9	73	20	14	45	25	14	50	4	7	8	4	4	7	2	0	3	0	12	1	1.33	0
1913	123	3	450	36	1	161	22	1	73	14	12	42	21	9	54	9	5	20	7	11	15	2	15	5	1	4	2	0	0	0	0	0	0	4.22	3
1914	130	7	368	36	1	119	44	10	124	26	15	67	17	5	39	3*	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.11	6
1915	185	6	518	12	4	47	29	14	95	31	14	94	71	6	188	27	11	65	11	1	24	0	8	1	0	0	0	0	0	0	0	0	0	3.56	8
Average	**139.1**		**401**	**22.4**		**86**	**26.2**		**79**	**20.4**		**56**	**35.2**		**89**	**15.2**		**34**	**11.2**		**22**	**2.0**		**4**	**1.4**		**2**	**0.5**		**1**	**0.2**	**0.3**	**3.31**	**4**
33, tree No. 23-87-6, Valencia strain:																																			
Orchard grade—																																			
1912	77	3	158	0	4	1	1	12	5	3	3	8	15	6	38	11	0	24	27	3	52	5	9	10	7	14	13	5	0	7	0	0	0	.33	....
1913	98	2	343	45	4	190	30	1	95	11	14	33	6	13	17	1	14	4	1	9	3	0	0	0	0	11	1	0	0	0	0	0	0	3.33	....
1914	129	15	393	44	6	180	41	13	113	24	15	60	13	12	30	4	8	9	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	3.66	....
1915	125	5	353	11	10	43	21	0	68	27	10	81	47	0	121	11	6	26	5	10	12	1	1	2	0	0	0	0	0	0	0	0	0	5.33	....
Average	107.6		312	25.4		104	23.7		70	16.8		46	20.7		52	7.2		16	8.6		17	1.8		3	2.1		4	1.3		2	0		0	3.16	....
Standard grade—																																			
1912	35	13	75	0	7	2	1	6	4	3	5	9	5	13	14	4	14	10	11	7	21	3	5	6	5	4	9	0	0	0	0	0	0	1.00	....
1913	17	5	84	13	9	76	1	4	4	0	0	0	0	7	1	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	1	8	2	3.00	....
1914	11	2	35	6	12	25	1	12	5	0	6	1	0	7	1	0	0	0	0	9	1	0	0	0	1	4	2	0	0	0	0	0	0	3.00	....
1915	25	0	81	7	6	30	8	0	26	4	15	14	1	15	5	2	3	5	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	5.33	....
Average	22.3		69	6.9		33	3.1		10	2.2		6	2.2		5	1.8		4	3.1		6	1.0		2	1.6		3	0		0	0.5	0.5	3.08	....
Cull fruits—																																			
1912	15	2	32	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.33	....
1913	3	9	43	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.33	....
1914	2	5	16	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	4.00	....
1915	14	4	12	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	5.00	....
Average	8.8		26	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	3.42	....
Total crop—																																			
1912	128	2	265	0	11	3	3	2	9	6	8	17	21	3	52	15	14	34	38	10	73	8	14	16	13	2	22	5	0	7	0	0	0	1.22	6
1913	119	0	470	58	13	266	31	5	99	11	14	33	7	4	18	1	14	4	2	2	4	0	0	0	0	11	1	0	0	0	1	8	2	2.89	2
1914	143	6	444	51	2	205	43	9	118	25	5	61	14	3	31	4	8	9	0	9	1	0	9	1	1	4	2	0	0	0	0	0	0	3.56	15
1915	164	9	446	19	0	73	29	0	94	32	9	95	48	15	126	13	9	31	5	10	12	1	10	3	0	0	0	0	0	0	0	0	0	5.22	7
Average	**138.8**		**406**	**32.4**		**137**	**26.8**		**80**	**19.1**		**52**	**22.9**		**57**	**9.0**		**20**	**11.7**		**23**	**2.8**		**5**	**3.8**		**6**	**1.3**		**2**	**0.4**	**0.5**	**3.22**	**8**
34, tree No. 23-91-5, Valencia strain:																																			
Orchard grade—																																			
1912	168	13	266	3	7	13	9	4	29	12	15	37	32	0	80	24	6	54	20	0	40	3	13	7	2	5	5	0	11	1	0	0	0	.67	....
1913	68	2	235	26	13	110	21	13	72	11	12	34	6	11	17	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1914	129	11	427	79	14	288	32	8	95	14	13	38	2	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.00	....
1915	83	0	239	7	9	27	15	4	49	29	4	85	26	8	68	3	15	9	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	6.33	....
Average	97.4		292	29.4		110	19.7		61	17.2		49	16.9		43	7.2		16	5.3		11	1.0		2	0.6		1	0.2		0.3	0		0	4.33	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
34. tree No. 23-91-5, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	62 4	151	4 4	16	5 0	15	12 7	34	14 11	36	7 0	15	11 15	23	1 1	2	5 14	10	0 0	0	0 0	0	1.33	....
1913	36 2	130	25 11	116	3 6	11	0 11	2	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
1914	24 4	97	20 12	86	2 12	9	0 6	1	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1915	27 10	94	9 2	37	9 6	32	5 8	16	1 15	5	1 11	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.00	....
Average	36.1	118	15.0	64	5.1	17	4.8	13	4.3	11	2.2	5	3.0	6	0.3	0.5	1.5	3	0	0	0	0	4.33	....
Cull fruits—																								
1912	10 11	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1913	3 10	68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.33	....
1914	3 3	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.00	....
1915	3 4	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.33	....
Average	5.2	35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.17	....
Total crop—																								
1912	181 12	445	7 11	29	14 4	44	25 6	71	46 11	116	31 6	69	31 15	63	4 14	9	8 3	15	0 11	1	0 0	0	1.33	0
1913	101 14	433	52 8	226	25 3	83	12 7	36	7 1	18	0 8	1	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	5.00	0
1914	157 2	549	100 10	374	35 4	104	15 3	39	2 14	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.89	6
1915	113 14	351	16 11	64	24 10	81	34 12	101	28 7	73	5 10	13	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	5.89	1
Average	**138.7**	**445**	**44.4**	**173**	**24.9**	**78**	**21.9**	**62**	**21.3**	**54**	**9.4**	**21**	**8.3**	**16**	**1.2**	**2**	**2.1**	**4**	**0.2**	**0.3**	0	0	**4.28**	**2**
35, tree No. 23-88-6, Valencia strain:																								
Orchard grade—																								
1912	100 9	227	2 6	8	6 2	18	9 13	26	28 3	67	24 4	52	22 2	43	3 5	6	2 6	4	2 0	3	0 0	0	1.00	....
1913	55 6	164	12 10	53	10 1	32	6 15	19	18 7	45	4 2	9	2 10	5	0 9	1	0 0	0	0 0	0	0 0	0	2.33	....
1914	173 11	573	115 2	410	41 11	120	14 6	37	2 8	6	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1915	103 13	28 0	4 0	15	11 4	36	23 2	68	45 14	117	14 15	34	4 10	10	0 0	0	0 0	0	0 0	0	0 0	0	6.67	....
Average	108.4	311	33.5	122	17.3	52	13.6	38	23.8	59	10.8	24	7.3	15	1.0	2	0.6	1	0.5	1	0	0	3.75	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
36, tree No. 23-91-8, Valencia strain—Continued.																								
Total crop—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	127 12	271	2 7	8	3 13	11	9 5	25	17 6	42	20 1	43	35 4	67	4 3	7	13 11	23	1 6	2	0 0	0	0.78	5
1913	101 8	431	53 4	226	22 6	71	12 14	36	4 13	12	2 5	5	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	3.78	1
1914	146 11	425	49 2	167	44 14	127	31 5	79	15 14	36	2 6	5	1 10	3	0 0	0	0 0	0	0 0	0	0 0	0	2.67	22
1915	165 5	508	20 8	77	44 15	147	42 11	125	43 1	113	10 9	25	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	5.00	21
Average	135.3	409	31.3	120	29.0	89	24.1	66	20.3	51	8.8	29	9.7	19	1.0	2	3.4	6	0.3	0.5	0	0	3.06	12
37, tree No. 23-93-7, Valencia strain:																								
Orchard grade—																								
1912	30 5	48	0 0	0	0 0	0	0 0	0	0 7	1	1 7	3	3 6	6	2 6	4	6 10	11	16 1	23	0 0	0	0	....
1913	78 11	267	28 8	117	24 14	81	12 4	36	8 2	22	3 0	7	1 6	3	0 0	0	0 9	1	0 0	0	0 0	0	2.00	....
1914	73 15	193	12 10	42	19 0	52	18 12	46	15 8	34	7 8	15	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1915	134 6	390	12 3	44	22 8	73	37 14	113	49 14	132	9 4	22	2 11	6	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
Average	79.3	224	13.3	51	16.6	52	17.2	49	18.5	47	5.3	12	2.0	4	0.6	1	1.8	3	4.0	6	0	0	2.50	....
Standard grade—																								
1912	52 2	98	0 0	0	0 5	1	2 3	6	3 7	8	10 12	22	16 11	31	0 10	1	18 2	29	0 0	0	0 0	0	.33	....
1913	29 13	132	25 2	118	3 2	10	0 10	2	0 8	1	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1914	58 2	154	9 12	35	10 14	32	10 2	26	16 10	39	8 2	17	2 10	5	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	40 12	138	8 5	35	21 10	73	7 15	23	2 0	5	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
Average	45 2	131	10.8	47	9.0	29	5.2	14	5 6	13	5 1	11	4.8	9	0.2	0.3	4.5	7	0	0	0	0	2.42	....
Cull fruits—																								
1912	31 1	55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1913	4 6	63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.00	....
1914	1 2	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
1915	2 9	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.33	....
Average	9.8	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.42	....

Total crop—																														
1912	113	8	201	0	0	0	0	5	1	2	3	6	3	14	9	12	3	25	20	1	37	3	0	5	24	12	40	16	1	23	0	0	0	.33	1
1913	112	14	462	53	10	235	28	0	91	12	14	38	8	10	23	3	7	8	1	6	3	0	0	0	0	9	1	0	0	0	0	0	0	3.11	4
1914	133	3	348	22	6	77	29	14	84	28	14	72	32	2	73	15	10	32	3	3	6	0	0	0	0	0	0	0	0	0	0	0	0	3.00	14
1915	177	11	541	20	8	79	44	2	146	45	13	136	51	14	137	10	2	24	2	11	6	0	0	0	0	0	0	0	0	0	0	0	0	4.67	12
Average	**134.3**		**388**	**24.1**		**98**	**25.6**		**81**	**22.4**		**63**	**24.1**		**61**	**10.3**		**22**	**6.8**		**13**	**0.8**		**1**	**6.3**		**10**	**4.0**		**6**	**0**		**0**	**2.78**	**8**
38, tree No. 23-90-10, Valencia strain:																																			
Orchard grade—																																			
1912	82	11	178	0	4	1	1	11	5	2	14	8	11	11	29	23	15	53	30	0	61	3	15	7	6	7	11	1	14	3	0	0	0	.33	....
1913	73	12	314	33	0	137	10	14	99	11	6	32	14	5	37	3	3	7	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1914	120	2	376	69	12	239	34	4	97	14	4	36	1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	108	15	291	4	11	17	13	11	42	22	4	63	50	11	130	13	11	31	3	6	7	0	9	1	0	0	0	0	0	0	0	0	0	3.33	....
Average	96.4		290	26.9		99	15.1		61	12.7		35	19.6		50	10.2		23	8.6		18	1.1		2	1.6		3	0.5		1	0		0	3.17	....
Standard grade—																																			
1912	63	11	132	1	4	4	1	5	4	3	8	9	14	13	35	10	5	22	22	2	40	1	2	2	9	4	16	0	0	0	0	0	0	1.67	....
1913	17	12	77	13	15	65	2	6	8	1	1	3	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1914	13	10	50	8	14	37	2	13	9	0	6	1	0	7	1	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1915	34	11	104	14	2	18	8	11	28	10	3	29	7	11	20	3	8	8	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
Average	32.4		91	9.5		31	3.8		12	3.8		11	5.8		14	3.5		8	5.9		11	0.3		0.5	2.3		4	0		0	0		0	4.09	
Cull fruits—																																			
1912	15	5	32																															.33	....
1913	3	13	52																															6.00	....
1914	0	10	3																															2.00	....
1915	0	11	5																															4.33	....
Average	5.1		23																															3.17	....
Total crop—																																			
1912	161	11	342	1	8	5	3	0	9	6	6	17	26	8	64	34	4	75	52	2	101	5	1	9	15	11	27	1	14	3	0	0	0	.78	1
1913	95	5	443	46	15	202	13	4	107	12	7	35	14	11	38	3	3	7	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5.11	0
1914	134	6	429	78	10	276	37	1	106	14	10	37	2	5	5	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	3.89	5
1915	144	5	400	8	13	35	22	6	70	32	7	92	58	6	150	17	3	39	3	14	8	0	9	1	0	0	0	0	0	0	0	0	0	4.11	7
Average	**133.9**		**404**	**34.0**		**130**	**18.9**		**73**	**16.5**		**45**	**25.5**		**64**	**12.7**		**30**	**14.5**		**28**	**1.4**		**3**	**3.9**		**7**	**0.5**		**1**	**0**		**0**	**3.47**	**3**
39, tree No. 23-76-17, Valencia strain:																																			
Orchard grade—																																			
1912	82	2	183	0	4	1	2	11	9	5	2	15	16	4	41	19	15	44	26	0	52	6	2	11	5	2	9	0	10	1	0	0	0	1.33	....
1913	117	8	379	34	7	133	43	7	137	23	5	67	15	14	41	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1914	92	12	235	15	0	48	19	12	54	29	10	72	22	14	50	3	14	8	1	10	3	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	127	14	336	2	8	9	13	2	42	24	4	70	55	2	142	19	9	45	11	4	24	2	1	4	0	0	0	0	0	0	0	0	0	6.67	....
Average	105.1		283	13.1		48	19.8		61	20.6		56	27.5		69	11.0		25	9.7		20	2.0		4	1.3		2	0.2		0.3	0		0	3.83	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
39, tree No. 23-76-17, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	19 7	45	0 15	3	1 6	4	1 10	4	6 8	16	3 14	8	4 9	9	0 9	1	0 0	0	0 0	0	0 0	0	0.33	....
1913	25 7	109	20 6	92	4 7	15	0 10	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1914	11 3	33	2 4	9	5 1	15	0 12	2	2 3	5	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	32 7	101	2 14	13	11 0	37	9 10	28	7 10	20	0 13	2	0 0	0	0 8	1	0 0	0	0 0	0	0 0	0	4.67	....
Average	22.1	72	6.6	29	5.5	18	3.2	9	4.1	10	1.4	3	1.1	2	0.3	0.5	0	0	0	0	0	0	3.25	....
Cull fruits—																								
1912	0 5	2																					0	....
1913	4 11	63																					4.67	....
1914	0 8	3																					3.00	....
1915	2 7	13																					4.00	....
Average	2.0	20																					2.92	....
Total crop—																								
1912	101 14	230	1 3	4	4 1	13	6 12	19	22 12	57	23 13	52	30 9	61	6 11	12	5 2	9	0 10	1	0 0	0	.71	0
1913	147 10	551	54 13	225	47 14	152	23 15	69	15 14	41	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.11	0
1914	104 7	271	17 4	57	24 13	69	30 6	74	25 1	55	4 13	10	1 10	3	0 0	0	0 0	0	0 0	0	0 0	0	3.56	2
1915	162 12	450	5 6	22	24 2	79	33 14	98	62 12	162	20 6	47	11 4	24	2 9	5	0 0	0	0 0	0	0 0	0	5.11	4
Average	129.2	376	19.7	77	25.2	78	23.7	65	31.6	79	12.4	28	10.9	22	2.3	4	1.3	2	0.2	0.3	0	0	3.33	2
40, tree No. 23-76-18, Corrugated strain:																								
Orchard grade—																								
1912	35 0	93	1 0	4	5 3	17	8 7	24	10 12	27	7 1	16	2 9	5	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1913	38 1	116	8 7	32	11 12	37	9 7	27	7 8	18	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1914	42 3	122	16 14	57	11 12	32	8 4	21	3 13	9	1 8	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1915	34 8	81	0 3	1	0 9	2	3 4	9	12 8	31	8 14	20	8 0	16	1 2	2	0 0	0	0 0	0	0 0	0	4.67	....
Average	37.4	103	6.6	24	7.4	22	7.3	20	8.6	21	4.6	10	2.6	5	0.3	0.5	0	0	0	0	0	0	3.59	....

Standard grade—																														
1912	120	1	291																									1.33		
1913	77	5	263																									4.33		
1914	87	15	253	26	6	94	20	5	59	14	0	37	17	2	41	5	6	12	4	3	9	0	9	1	0	0	0	0	0	0	0	1.67		
1915	74	4	188	1	13	7	7	3	24	17	0	47	20	3	50	21	10	48	4	0	8	1	12	3	0	11	1	0	0	0	0	2.00		
Average	89.9		249																									2.33		
Cull fruits—																														
1912	0	0	0																									0		
1913	2	8	35																									4.00		
1914	0	4	4																									2.67		
1915	0	8	3																									2.00		
Average	0	8	11																									2.17		
Total crop—																														
1912	155	1	384																									1.11	116	
1913	117	14	414																									3.67	202	
1914	130	6	379	43	4	151	32	1	91	22	4	58	20	15	50	6	14	15	4	3	9	0	9	1	0	0	0	0	0	0	0	3.11	155	
1915	109	4	272	2	0	8	7	12	26	20	4	56	32	11	81	30	8	68	12	0	24	2	14	5	0	11	1	0	0	0	0	2.89	146	
Average	123.1		362																									2.70	155	
41, tree No. 23-87-7, Corrugated strain:																														
Orchard grade—																														
1912	28	12	74	1	1	4	4	3	13	5	10	16	8	6	21	3	9	8	4	4	9	0	8	1	0	9	1	0	10	1	0	0	0	1.33		
1913	22	12	65	3	15	15	7	10	23	3	6	9	5	7	13	1	14	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	1.33		
1914	18	8	55	6	3	22	8	12	24	3	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33		
1915	17	6	40	0	4	2	1	3	4	0	11	2	5	6	13	3	6	7	3	0	6	2	13	5	0	0	0	0	11	1	0	0	0	4.33		
Average	21	8	59	2.9		11	5.4		16	3.3		9	4.8		12	2.2		5	1.9		4	0.8		2	0.1		0.3	0.3		0.5	0		0	2.33		
Standard grade—																														
1912	137	15	386																									3.33		
1913	124	13	362																									3.33		
1914	103	15	329	49	12	179	32	13	96	13	8	36	6	0	14	1	6	3	0	8	1	0	0	0	0	0	0	0	0	0	0	1.67		
1915	44	2	108	2	0	8	4	13	15	8	2	22	6	6	16	16	3	35	3	2	6	2	4	4	1	4	2	0	0	0	0	2.33		
Average	102.7		296																									2.67		
Cull fruits—																														
1912	0	0	0																									0		
1913	2	0	19																									1.67		
1914	2	1	13																									4.67		
1915	1	0	3																									1.67		
Average	1.3		9																									2.00		

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Total.		Sizes. 288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Average number of seeds per fruit.	Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
41, tree No. 23-87-7, Corrugated strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	166 11	460																					1.55	116
1913	119 9	146																					2.11	117
1914	124 8	397	55 15	201	41 9	120	17 1	45	6 0	14	1 6	3	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.89	75
1915	62 8	151	2 4	10	6 0	19	8 13	24	11 12	29	19 9	42	6 2	12	5 1	9	1 4	2	0 11	1	0 0	0	2.78	58
Average	125.8	364																					2.33	91
42, tree No. 23-89-2, Valencia strain:																								
Orchard grade—																								
1912	46 3	101	0 4	1	2 0	6	2 7	7	7 14	20	10 4	23	13 15	28	2 2	4	5 6	9	1 15	3	0 0	0	2.67	....
1913	91 13	331	47 6	198	27 14	89	9 10	27	6 0	15	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.90	....
1914	121 9	379	64 13	227	33 4	94	17 10	45	4 13	11	0 8	1	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
1915	55 9	145	1 5	5	6 14	22	9 4	27	23 8	60	7 15	18	4 14	10	1 2	2	0 11	1	0 0	0	0 0	0	2.67	....
Average	78.8	239	28.4	108	17.5	53	9.7	27	10.5	27	4.9	11	1.8	10	0.8	2	1.5	3	0.5	1	0	0	3.25	....
Standard grade—																								
1912	66 11	152	5 3	16	3 1	9	7 9	20	18 2	42	12 12	27	15 6	30	1 0	2	3 10	6	0 0	0	0 0	0	.67	....
1913	29 10	138	25 15	126	2 12	10	0 6	1	0 0	0	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1914	20 1	76	13 11	56	5 12	18	0 10	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
1915	48 0	136	3 2	14	11 2	37	11 8	33	11 5	29	7 2	16	2 1	4	1 2	2	0 10	1	0 0	0	0 0	0	3.67	....
Average	41.1	126	12.0	53	5.7	19	5.0	14	7.4	18	5.1	11	4.4	9	0.5	1	1.1	2	0	0	0	0	3.17	....
Cull fruits—																								
1912	11 13	32																					0	....
1913	7 8	125																					1.67	....
1914	1 4	9																					4.67	....
1915	1 8	6																					4.67	....
Average	5.5	43																					2.78	....

Total crop—																														
1912	124	11	285	5	7	17	5	1	15	10	0	27	26	0	62	23	0	50	29	5	58	3	2	6	9	0	15	1	15	3	0	0	0	1.00	6
1913	128	15	594	73	5	324	30	10	99	10	0	28	6	0	15	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.11	7
1914	142	14	464	78	8	283	39	0	112	18	4	47	4	13	11	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	5.33	136
1915	105	1	287	4	7	19	18	0	59	20	12	60	34	13	89	15	1	34	6	15	14	2	4	4	1	5	2	0	0	0	0	0	0	3.67	45
Average	**125.4**		**408**	**40.4**		**161**	**23.2**		**71**	**14.8**		**41**	**17.9**		**44**	**10.0**		**22**	**9.2**		**18**	**1.3**		**3**	**2.6**		**4**	**0.5**		**1**	**0**		**0**	**3.04**	**49**
43, tree No. 23-93-8, Valencia strain:																																			
Orchard grade—																																			
1912	37	7	70	0	4	1	0	0	0	0	12	2	6	2	14	2	12	6	9	6	18	1	11	3	9	10	16	6	14	10	0	0	0	0	....
1913	87	2	260	11	15	49	27	4	88	17	5	50	18	1	46	9	8	21	2	8	5	0	0	0	0	9	1	0	0	0	0	0	0	2.00	....
1914	101	1	277	27	5	91	27	4	77	27	0	68	15	4	33	2	0	4	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	138	3	353	5	13	20	9	9	29	22	6	64	63	3	160	22	9	51	10	11	22	4	0	7	0	0	0	0	0	0	0	0	0	4.00	....
Average	91.0		240	11.3		40	16.0		49	16.9		46	25.7		63	9.2		21	6.2		12	1.4		3	2.5		4	1.7		3	0		0	2.17	....
Standard grade—																																			
1912	31	7	62	0	4	1	1	0	3	1	2	3	3	4	8	4	4	9	10	5	19	2	12	5	8	8	14	0	0	0	0	0	0	.33	....
1913	30	0	113	17	6	75	7	8	24	3	15	11	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	....
1914	19	0	63	11	11	44	3	15	12	1	4	3	0	7	1	0	8	1	0	9	1	0	10	1	0	0	0	0	0	0	0	0	0	5.00	....
1915	41	13	120	3	5	13	10	0	33	14	3	40	7	3	18	6	2	14	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
Average	30.6		90	8.2		33	5.6		18	5.1		14	3.0		8	2.9		6	3.0		6	0.8		2	2.1		4	0		0	0		0	2.42	....
Cull fruits—																																			
1912	7	1	11																															1.33	....
1913	3	13	46																															2.33	....
1914	1	10	8																															1.67	....
1915	2	4	10																															2.67	....
Average	3.7		19																															2.00	....
Total crop—																																			
1912	75	15	143	0	8	2	1	0	3	1	14	5	9	6	22	7	0	15	19	11	37	4	7	8	18	2	30	6	14	10	0	0	0	.56	1
1913	120	15	419	29	5	124	34	12	112	21	4	61	19	4	49	9	8	21	2	8	5	0	0	0	0	9	1	0	0	0	0	0	0	1.78	0
1914	121	11	348	39	0	135	31	3	89	28	4	71	15	11	34	2	8	5	2	13	5	0	10	1	0	0	0	0	0	0	0	0	0	3.11	1
1915	182	4	483	9	2	33	19	9	62	36	9	104	70	6	178	28	11	65	11	11	24	4	0	7	0	0	0	0	0	0	0	0	0	3.33	2
Average	**125.2**		**348**	**19.5**		**74**	**21.6**		**67**	**22.0**		**60**	**28.7**		**71**	**11.9**		**27**	**9.2**		**18**	**2.3**		**4**	**4.7**		**8**	**1.7**		**3**	**0**		**0**	**2.19**	**1**
44, tree No. 23-90-7, Sporting strain:																																			
Orchard grade—																																			
1912	44	1	93	0	9	2	1	10	5	0	7	1	9	6	23	9	0	20	10	1	20	3	4	6	5	11	10	4	1	6	0	0	0	2.00	....
1913	75	12	257	27	4	114	24	11	80	10	7	30	9	3	24	2	11	6	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	2.00	....
1914	66	14	168	11	0	35	14	2	39	17	15	44	16	8	36	5	9	11	1	12	3	0	0	0	0	0	0	0	0	0	0	0	0	2.00	....
1915	44	3	115	0	12	3	4	12	15	7	2	21	15	6	40	10	0	23	5	10	12	0	9	1	0	0	0	0	0	0	0	0	0	3.00	....
Average	57.7		158	9.9		39	11.3		35	9.0		24	12.6		31	6.8		15	4.7		10	1.0		2	1.4		3	1.0		2	0		0	2.25	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
44, tree No. 23-90-7, Sporting strain—Continued.																								
Standard grade—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	49 12	104	1 10	6	1 12	5	4 6	12	6 11	16	6 7	14	13 8	25	1 1	2	14 5	24	0 0	0	0 0	0	0.67	.....
1913	35 12	158	27 11	135	4 3	14	1 15	5	0 8	1	0 6	1	1 1	2	0 0	0	0 0	0	0 0	0	0 0	0	4.00	.....
1914	52 5	140	9 2	34	10 3	31	8 2	22	10 8	24	7 6	16	4 8	9	0 0	0	0 10	1	1 14	3	0 0	0	3.67	.....
1915	78 8	232	4 12	20	15 0	50	19 8	66	23 3	60	13 0	30	2 8	5	0 9	1	0 0	0	0 0	0	0 0	0	4.33	.....
Average	54.1	159	10.8	49	7.8	25	8.5	25	10.2	25	6.8	15	5.4	10	0.4	1	3.9	6	0.5	1	0	0	3.17	.....
Cull fruits—																								
1912	46 8	104	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....
1913	4 1	64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	.....
1914	1 1	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.67	.....
1915	2 0	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	.....
Average	13.4	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.34	.....
Total crop—																								
1912	140 5	301	2 3	8	3 6	10	4 13	13	16 1	39	15 7	34	23 9	45	4 5	8	20 0	34	4 1	6	0 0	0	.89	104
1913	115 9	479	54 15	249	28 14	94	12 6	35	9 11	25	3 1	7	2 9	5	0 0	0	0 0	0	0 0	0	0 0	0	2.89	51
1914	120 4	313	20 2	69	24 5	70	26 1	66	27 0	60	12 15	27	6 4	12	0 0	0	0 10	1	1 14	3	0 0	0	3.45	111
1915	124 11	358	5 8	23	19 12	65	26 10	87	38 9	100	23 0	53	8 2	17	1 2	2	0 0	0	0 0	0	0 0	0	3.11	112
Average	**125.2**	**363**	**20.7**	**87**	**19.1**	**60**	**17.5**	**50**	**22.8**	**56**	**13.6**	**30**	**10.1**	**20**	**1.3**	**3**	**5.2**	**9**	**1.5**	**2**	**0**	**0**	**2.59**	**95**
45, tree No. 23-91-7, Valencia strain:																								
Orchard grade—																								
1912	37 9	82	1 5	5	2 4	7	2 3	6	6 15	17	4 14	11	9 4	19	0 9	1	3 9	6	6 10	10	0 0	0	2.33	.....
1913	88 12	299	33 0	138	30 11	97	7 2	21	11 13	30	3 15	9	1 9	3	0 0	0	0 10	1	0 0	0	0 0	0	3.33	.....
1914	74 5	214	22 6	77	26 6	75	14 9	37	10 8	24	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	.....
1915	53 6	141	2 4	8	4 8	14	9 6	27	23 13	62	11 8	26	1 15	4	0 0	0	0 0	0	0 0	0	0 0	0	3.67	.....
Average	63.5	184	14.7	57	16.0	48	8.3	23	13.3	33	5.2	12	3.2	7	0.1	0.3	1.1	2	1.7	3	0	0	2.92	.....

Standard grade—																																
1912	64 0	139	1 11	6	3 7	10	3 8	10	11 13	29	12 1	26	18 5	35	3 12	7	9 7	16	0 0	0	0 0	0	0	0	....
1913	30 7	130	22 4	105	5 12	18	2 0	6	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1914	53 4	182	30 13	120	13 2	41	3 0	8	2 1	5	2 0	4	2 4	4	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	50 6	149	6 6	27	15 10	51	10 6	30	11 13	29	4 8	10	1 0	2	0 0	0	0 11	1	0 0	0	0 0	0	3.00	....
Average	49.5	150	15.3	65	9.5	30	4.7	14	6.5	16	4.6	10	5.4	10	0.9	2	2.5	4	0	0	0	0	2.83	....
Cull fruits—																																
1912	38 6	89																					0	....
1913	5 6	64																					4.33	....
1914	1 6	8																					2.00	....
1915	3 8	14																					2.33	....
Average	12.2	44																					2.17	....
Total crop—																																
1912	139 15	310	3 0	11	5 11	17	5 11	16	18 12	46	16 15	37	27 9	54	4 5	8	13 0	22	6 10	10	0 0	0	.78	45
1913	124 9	493	55 4	243	36 7	115	9 2	27	12 4	31	3 15	9	1 9	3	0 0	0	0 10	1	0 0	0	0 0	0	4.00	16
1914	128 15	404	53 3	197	39 8	116	17 9	45	12 9	29	2 8	5	2 4	4	0 0	0	0 0	0	0 0	0	0 0	0	2.78	100
1915	107 4	304	8 10	35	20 2	65	19 12	57	35 10	91	16 0	36	2 15	6	0 0	0	0 11	1	0 0	0	0 0	0	3.00	43
Average	125.2	378	30.0	122	25.4	78	13.0	36	19.8	49	9.8	22	8.6	17	1.1	2	3.6	6	1.7	3	0	0	2.64	51
46, tree No. 23-88-1, Valencia strain:																																
Orchard grade—																																
1912	72 12	172	2 11	11	7 13	24	5 4	15	18 2	44	12 15	28	19 7	39	2 12	5	2 6	4	1 6	2	0 0	0	1.00	....
1913	74 4	281	50 1	207	16 2	52	6 1	17	2 0	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1914	100 2	274	28 0	92	33 4	93	22 2	54	12 8	27	2 8	5	1 12	3	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1915	87 10	275	16 2	60	27 8	90	22 12	68	19 3	52	2 1	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
Average	83.7	251	24.2	93	21.2	65	14.0	39	13.0	32	4.4	10	5.3	11	0.7	1	0.6	1	0.3	0.5	0	0	3.42	....
Standard grade—																																
1912	56 2	125	1 15	8	2 1	6	8 4	22	11 15	28	12 8	26	11 13	22	1 11	3	5 15	10	0 0	0	0 0	0	1.33	....
1913	30 7	140	28 5	133	2 2	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	19 2	57	6 4	25	3 0	9	4 8	12	2 3	5	1 8	3	1 11	3	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1915	36 10	128	10 10	44	15 4	53	8 1	24	2 11	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
Average	35.6	113	11.8	53	5.6	19	5.2	15	4.2	10	3.5	7	3.4	6	0.2	1	1.5	3	0	0	0	0	3.67	....
Cull fruits—																																
1912	12 9	28																					1.00	....
1913	5 4	66																					5.67	....
1914	1 8	9																					1.33	....
1915	2 0	10																					5.67	....
Average	5.3	28																					3.42	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
46, tree No. 23-88-1, Valencia strain—Continued.																								
Total crop—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	141 7	325	4 10	19	9 14	30	13 8	37	30 1	72	25 7	54	31 4	61	4 7	8	8 5	14	1 6	2	0 0	0	1.11	4
1913	109 15	487	78 6	340	18 4	59	6 1	17	2 0	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.75	1
1914	120 12	340	34 4	117	36 4	102	26 10	66	14 11	32	4 0	8	3 7	6	0 0	0	0 0	0	0 0	0	0 0	0	3.00	21
1915	126 4	413	26 12	104	42 12	143	30 13	92	21 14	59	2 1	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.33	13
Average	**124.6**	**391**	**36.0**	**145**	**26.8**	**84**	**19.0**	**53**	**17.2**	**42**	**7.9**	**17**	**8.7**	**17**	**1.1**	**2**	**2.1**	**4**	**0.3**	**0.5**	**0**	**0**	**3.55**	**10**
47, tree No. 23-85-7, Corrugated strain:																								
Orchard grade—																								
1912	18 1	39	0 0	0	0 10	2	1 14	5	3 2	8	3 5	7	7 5	14	0 0	0	1 2	2	0 11	1	0 0	0	.67	....
1913	31 1	89	5 5	22	6 4	20	5 6	15	7 7	18	3 11	8	3 0	6	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1914	20 14	61	10 1	33	7 1	19	2 14	7	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.67	....
1915	43 8	103	0 0	0	2 0	7	2 4	7	15 3	39	8 13	20	8 14	18	6 6	12	0 0	0	0 0	0	0 0	0	6.33	....
Average	28.4	73	3.8	14	4.0	12	3.1	9	6.7	17	4.0	9	4.8	10	1.6	3	0.3	0.5	0.2	0.3	0	0	4.67	....
Standard grade—																								
1912	119 9	266	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.33	....
1913	76 2	216	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
1914	114 4	339	46 10	165	33 10	96	12 6	31	15 11	36	3 11	7	2 4	4	0 0	0	0 0	0	0 0	0	0 0	0	1.00	....
1915	63 14	161	4 1	15	8 10	26	10 12	29	14 6	36	18 2	40	4 15	10	2 5	4	0 11	1	0 0	0	0 0	0	2.67	....
Average	93.5	246	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.11	....
Cull fruits—																								
1912	2 13	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	3 4	36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1914	2 7	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1915	0 10	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	....
Average	2.3	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.59	....

Total crop—																												
1912	140 7	314																								.67	63
1913	110 7	341																								3.00	158
1914	137 9	412	56 11	198	40 11	115	15 4	38	16 9	38	3 11	7	2 4	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.78	90
1915	108 0	267	4 1	15	10 10	33	13 0	36	29 9	75	26 15	60	13 13	28	8 11	16	0 11	1	0 0	0	0 0	0	0 0	0	3.33	135
Average	**124.1**	**334**																							**2.45**	**112**
48, tree No. 23-90-4, Valencia strain:																												
Orchard grade—																												
1912	77 9	171	2 2	8	6 15	22	3 4	9	13 2	32	13 2	35	19 11	38	5 3	9	9 1	15	2 1	3	0 0	0	.33	....				
1913	60 7	202	24 13	99	18 11	59	8 10	24	5 6	14	1 13	4	1 2	2	0 0	0	0 0	0	0 0	0	0 0	0	1.00	....				
1914	119 14	377	66 11	233	36 3	102	11 14	30	5 2	12	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....				
1915	79 11	223	5 1	19	11 2	36	22 8	66	31 1	80	6 9	15	3 6	7	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....				
Average	84.4	243	24.7	90	18.2	55	11.6	32	13.7	35	5.4	14	6.1	12	1.3	2	2.3	4	0.5	1	0	0	2.50	....				
Standard grade—																												
1912	46 7	107	3 9	13	3 6	10	6 8	17	10 6	24	9 12	20	8 11	16	1 1	2	3 2	5	0 0	0	0 0	0	1.33	....				
1913	21 9	91	16 15	77	2 2	7	1 14	5	0 10	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....				
1914	20 14	77	14 0	57	4 8	14	1 10	2	1 4	3	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....				
1915	51 8	159	5 7	23	17 15	59	18 0	52	6 12	17	3 6	8	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....				
Average	35.1	109	10.0	43	7.0	23	7.0	19	4.8	12	3.4	7	2.3	4	0.3	0.5	0.8	1	0	0	0	0	3.58	....				
Cull fruits—																												
1912	8 8	17																					1.00	....				
1913	5 4	86																					1.67	....				
1914	1 12	9																					1.67	....				
1915	2 6	14																					1.33	....				
Average	4.5	32																					1.42	....				
Total crop—																												
1912	132 8	295	5 11	21	10 5	32	9 12	26	23 8	56	25 14	55	28 6	54	6 4	11	12 3	20	2 1	3	0 0	0	.89	0				
1913	87 4	379	41 12	176	20 13	66	10 8	29	6 0	16	1 13	4	1 2	2	0 0	0	0 0	0	0 0	0	0 0	0	2.22	1				
1914	142 8	463	80 11	290	40 11	116	12 8	32	6 6	15	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.22	35				
1915	133 9	396	10 8	42	29 1	95	40 8	118	37 13	97	9 15	23	3 6	7	0 0	0	0 0	0	0 0	0	0 0	0	3.67	33				
Average	**124.0**	**383**	**34.7**	**132**	**25.2**	**77**	**18.3**	**51**	**18.4**	**46**	**9.5**	**21**	**8.2**	**16**	**1.6**	**3**	**3.0**	**5**	**0.5**	**1**	**0**	**0**	**2.50**	**17**				
49, tree No. 23-76-22, Valencia strain:																												
Orchard grade—																												
1912	64 13	122	0 0	0	0 5	1	2 3	6	5 14	14	7 13	17	17 15	35	2 12	5	13 12	23	14 3	21	0 0	0	1.00	....				
1913	93 8	329	42 15	179	25 0	81	12 15	37	10 6	27	1 12	4	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	1.33	....				
1914	73 13	205	18 3	62	21 0	59	22 4	56	9 14	23	2 8	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....				
1915	67 9	184	2 12	10	10 14	34	14 10	42	29 7	76	6 15	16	2 15	6	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....				
Average	74.9	210	16.0	63	14.3	44	13.0	35	13.9	35	4.8	11	5.3	11	0.7	1	3.4	6	3.5	5	0	0	2.58	....				

TABLE 1.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
49, tree No. 23-76-22, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	24 8	49	0 8	2	0 5	1	1 4	3	2 10	6	1 14	4	9 12	19	1 2	2	7 1	12	0 0	0	0 0	0	1.00	....
1913	34 11	160	29 2	144	3 9	11	1 2	3	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1914	44 2	130	11 14	44	11 14	35	8 14	24	7 12	19	3 4	7	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1915	77 7	235	8 10	38	29 10	69	23 5	67	14 11	37	9 12	23	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
Average	15 2	144	12.5	57	9.1	29	8.6	24	6 5	16	3.7	9	2 7	5	0.3	0.5	1 8	3	0	0	0	0	3.17	....
Cull fruits—																								
1912	5 11	11																					.33	....
1913	3 13	51																					3.00	....
1914	1 7	13																					2.00	....
1915	3 6	17																					4.00	....
Average	3.6	23																					2.33	....
Total crop—																								
1912	95 0	182	0 8	2	0 10	2	3 7	9	8 8	20	9 11	21	27 11	54	3 14	7	20 13	35	14 3	21	0 0	0	.78	6
1913	132 0	540	72 1	323	28 9	92	14 1	40	11 4	29	1 12	4	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.33	3
1914	119 6	348	30 1	106	32 14	94	31 2	80	17 10	42	5 12	12	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	3.22	21
1915	148 6	436	11 6	48	31 8	103	37 15	109	44 2	113	16 11	29	3 6	7	0 0	0	0 0	0	0 0	0	0 0	0	4.44	41
Average	**123.7**	**377**	**28.5**	**120**	**23.4**	**73**	**21.6**	**60**	**20.4**	**51**	**8.5**	**17**	**8.0**	**16**	**1.0**	**2**	**5.2**	**9**	**3.5**	**5**	**0**	**0**	**2.69**	**18**
50, tree No. 23-88-8, Valencia strain:																								
Orchard grade—																								
1912	64 10	139	0 4	1	3 2	9	6 3	15	16 0	38	12 8	27	17 8	34	4 5	7	4 2	7	0 10	1	0 0	0	0	....
1913	82 2	276	28 10	118	28 5	91	13 5	37	10 15	28	0 7	1	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
1914	94 2	274	38 2	124	38 3	97	18 3	45	3 10	8	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	123 1	367	12 0	44	26 14	88	35 14	107	43 11	117	3 12	9	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
Average	91.0	264	19.8	72	24.1	71	18.4	51	18.6	48	5.7	9	4.7	9	1.1	2	1.3	2	0.1	0.3	0	0	3.67	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
51, tree No. 23-77-17, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	94 12	180	1 11	6	2 11	8	3 0	8	7 5	17	10 2	21	24 13	46	6 8	11	20 4	32	8 14	13	0 0	0	1.00	1
1913	110 4	422	41 4	182	24 12	82	17 11	51	19 12	49	2 11	6	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	4.22	0
1914	128 14	388	58 15	201	36 10	101	21 6	53	10 4	22	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	4
1915	157 13	414	5 0	18	19 9	62	31 15	90	64 6	161	25 9	57	9 12	20	1 2	2	0 0	0	0 0	0	0 0	0	4.22	10
Average	122.9	351	26.7	102	20.9	63	19 0	51	24 4	62	9.6	21	8.8	17	1.9	3	5.1	8	2.2	3	0	0	3.44	4
52, tree No. 23-89-8, Valencia strain:																								
Orchard grade—																								
1912	42 11	83	0 0	0	0 0	0	0 12	2	4 7	11	12 10	27	9 11	19	2 4	4	7 8	12	5 7	8	0 0	0	2.33	....
1913	97 8	343	43 9	184	31 2	100	8 8	24	11 7	29	2 4	5	0 0	0	0 0	0	0 10	1	0 0	0	0 0	0	3.33	....
1914	95 3	276	43 0	143	26 9	74	13 2	32	10 8	23	2 0	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	68 8	172	0 4	1	5 15	19	8 4	24	28 2	72	17 0	38	5 8	12	2 14	5	0 9	1	0 0	0	0 0	0	5.00	....
Average	76.0	219	21.7	82	15.9	48	7.7	21	13.6	34	8.5	19	3.8	8	1.3	2	2.2	4	1.4	2	0	0	3.50	....
Standard grade—																								
1912	61 4	130	0 10	2	3 14	11	4 7	12	13 2	31	11 10	24	16 6	31	1 11	3	9 8	16	0 0	0	0 0	0	2.67	....
1913	36 5	160	28 10	137	3 10	10	4 11	13	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1914	12 0	41	6 7	26	3 3	9	1 2	3	1 4	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	45 6	128	0 9	4	7 12	27	14 2	41	13 9	35	7 12	18	1 0	2	0 0	0	0 10	1	0 0	0	0 0	0	3.67	....
Average	38.7	115	9.1	42	4.6	14	6.1	17	7.0	17	4.8	11	4.3	8	0.4	1	2.5	4	0	0	0	0	3.00	....
Cull fruits—																								
1912	22 5	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.33	....
1913	5 6	75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
1914	2 12	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1915	1 0	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
Average	7.9	36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....

Total crop—																												
1912	126	4	260	0	10	2	3	14	11	5	3	14	17	9	42	24	4	51	26	1	50	3	15	7	17	0	28	5	7	8	0	0	0	2.22	5
1913	139	3	578	72	3	321	34	2	110	13	3	37	11	7	29	2	4	5	0	0	0	0	0	0	0	10	1	0	0	0	0	0	0	3.33	5
1914	109	15	334	49	7	169	29	12	83	14	4	35	11	12	26	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	43
1915	114	14	304	0	13	5	13	11	46	22	6	65	41	11	107	24	12	56	6	8	14	2	14	5	1	3	2	0	0	0	0	0	0	3.78	40
Average	**122.6**		**369**	**30.8**		**124**	**20.4**		**63**	**13.8**		**38**	**20.1**		**51**	**13.3**		**29**	**8.1**		**16**	**1.7**		**3**	**4.7**		**8**	**1.4**		**2**	**0**		**0**	**3.00**	**23**
53, tree No. 23-98-6, Valencia strain:																																			
Orchard grade—																																			
1912	76	8	164	0	12	3	3	3	10	3	8	10	13	3	32	15	6	34	25	8	50	5	10	10	4	2	7	5	4	8	0	0	0	.67	....
1913	78	13	256	26	0	108	22	2	70	14	8	40	11	15	29	3	1	7	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1914	87	3	286	57	0	202	19	14	58	8	9	22	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.00	....
1915	75	7	205	4	11	17	11	12	37	13	0	37	33	0	85	9	15	23	2	8	5	0	9	1	0	0	0	0	0	0	0	0	0	4.00	....
Average	79.5		228	22.1		83	14.2		44	9.9		27	15.0		38	7.1		16	7.3		14	1.5		3	1.0		2	1.3		2	0		0	3.78	....
Standard grade—																																			
1912	67	11	152	3	4	12	4	10	14	5	14	16	10	9	26	15	0	32	16	2	31	1	11	3	10	9	18	0	0	0	0	0	0	1.00	....
1913	18	13	90	16	3	82	1	3	4	1	0	3	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1914	22	4	85	15	8	65	4	7	14	0	11	2	1	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	37	2	123	7	15	33	15	3	51	9	2	27	2	4	6	2	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
Average	36.5		113	10.7		48	6.4		21	4.2		12	3.6		9	4.5		10	4.0		8	0.4		1	2.6		5	0		0	0		0	3.08	....
Cull fruits—																																			
1912	16	4	36																															1.00	....
1913	3	0	44																															5.33	....
1914	1	13	15																															2.67	....
1915	2	2	10																															5.00	....
Average	5.8		26																															3.50	....
Total crop—																																			
1912	160	7	352	4	0	15	7	13	24	9	6	26	23	12	58	30	6	66	41	10	81	7	5	13	14	11	25	5	4	8	0	0	0	.89	8
1913	100	10	390	42	3	190	23	5	74	15	8	43	11	15	29	3	8	8	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	4.67	4
1914	111	4	386	72	8	267	24	5	72	9	4	24	3	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.22	40
1915	114	11	338	12	10	50	26	15	88	22	2	64	35	4	91	12	9	29	2	8	5	0	9	1	0	0	0	0	0	0	0	0	0	4.00	13
Average	**121.8**		**367**	**32.8**		**131**	**20.6**		**65**	**14.1**		**39**	**18.6**		**47**	**11.6**		**26**	**11.3**		**22**	**3.0**		**4**	**3.7**		**6**	**1.3**		**2**	**0**		**0**	**3.45**	**16**
54, tree No. 23-86-8, Valencia strain:																																			
Orchard grade—																																			
1912	40	10	76	0	4	1	0	11	2	1	7	4	2	14	7	5	15	12	10	12	21	2	6	4	9	4	15	7	1	10	0	0	0	.67	....
1913	82	7	283	32	4	133	23	10	78	11	4	32	13	9	36	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.67	....
1914	58	10	134	4	14	14	11	6	30	13	2	31	18	0	38	10	2	19	0	8	1	0	0	0	0	10	1	0	0	0	0	0	0	2.00	....
1915	165	5	553	29	4	122	46	2	164	46	5	146	40	12	114	2	14	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
Average	86.8		262	16.7		68	20.2		69	18.0		53	18.8		49	5.2		11	2.8		6	0.6		1	2.5		4	1.8		3	0		0	2.25	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
54, tree No. 23-86-8, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	29 5	56	0 4	1	1 1	3	0 14	2	4 7	10	6 7	13	5 11	10	1 12	3	8 13	14	0 0	0	0 0	0	0.67	....
1913	28 2	117	20 9	94	3 11	13	2 9	7	0 6	1	0 7	1	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1914	9 14	26	2 10	9	1 6	4	1 8	4	1 12	4	0 8	1	2 2	4	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	47 10	189	35 8	150	9 12	32	2 0	6	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
Average	28.7	97	14.7	64	4.0	13	1.7	5	1.6	4	1.8	4	2.1	4	0.4	1	2.2	4	0	0	0	0	2.59	....
Cull fruits—																								
1912	9 1	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	7 14	79	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1914	0 6	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
1915	2 7	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.00	....
Average	4.9	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.58	....
Total crop—																								
1912	79 0	148	0 8	2	1 12	5	2 5	6	7 5	17	12 6	25	16 7	31	4 2	7	18 1	29	7 1	10	0 0	0	.44	0
1913	118 7	479	52 13	227	27 5	91	13 13	39	13 15	37	2 3	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.00	1
1914	68 14	162	7 8	23	12 12	34	14 10	35	19 12	42	10 10	20	2 10	5	0 0	0	0 10	1	0 0	0	0 0	0	3.00	9
1915	215 6	755	64 12	272	55 14	196	48 5	152	41 2	115	2 14	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.44	15
Average	**120.4**	**386**	**31.4**	**131**	**24.4**	**82**	**19.8**	**58**	**20.5**	**53**	**7.0**	**14**	**4.9**	**9**	**1.0**	**2**	**4.7**	**8**	**1.8**	**3**	**0**	**0**	**2.47**	**6**
55, tree No. 23-87-4, Valencia strain:																								
Orchard grade—																								
1912	69 7	156	1 10	6	4 4	13	6 10	18	16 2	38	7 0	37	16 8	32	1 11	3	4 14	8	0 12	1	0 0	0	2.00	....
1913	56 2	180	17 8	73	12 13	41	9 0	25	12 4	31	3 2	7	1 7	3	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1914	106 7	307	39 8	130	37 5	104	22 14	58	5 14	13	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	111 5	306	5 11	21	16 6	52	27 9	80	45 4	116	12 11	29	3 12	8	0 0	0	0 0	0	0 0	0	0 0	0	5.67	....
Average	85.8	237	16.1	58	17.7	53	16.5	45	19.9	50	5.9	19	5.4	11	0.4	1	1.2	2	0.2	0.3	0	0	3.33	....

Standard grade—																																
1912	36	11	80	1	7	5	1	12	5	5	5	14	9	1	21	7	15	16	5	10	10	0	9	1	5	0	8	0	0	0	0	0	1.67	....
1913	17	10	79	14	5	68	3	0	10	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.33	....
1914	29	5	98	14	1	55	8	10	26	4	6	12	1	4	3	0	8	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1915	31	5	99	5	5	21	13	10	44	8	7	24	3	0	8	0	7	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	6.33	....
Average	28.7		89	8.8		37	6.8		21	4.6		13	3.3		8	2.2		5	1.7		3	0.1		0.3	1.3		2	0		0	0	0	3.42	....
Cull fruits—																																		
1912	11	0	22																														3.00	....
1913	3	9	41																														1.67	....
1914	3	6	18																														3.67	....
1915	4	8	16																														4.33	....
Average	5.6		24																														3.17	....
Total crop—																																		
1912	117	2	258	3	1	11	6	0	18	11	15	32	25	3	59	24	15	53	22	2	42	2	4	4	9	14	16	0	12	1	0	0	2.22	6
1913	77	5	300	31	13	141	15	13	51	9	5	26	12	4	31	3	2	7	1	7	3	0	0	0	0	0	0	0	0	0	0	0	1.33	2
1914	139	2	423	53	9	185	45	15	130	27	4	70	7	2	16	1	6	3	0	8	1	0	0	0	0	0	0	0	0	0	0	0	4.22	28
1915	147	2	421	11	0	42	30	0	96	36	0	104	48	4	124	13	2	30	4	4	9	0	0	0	0	0	0	0	0	0	0	0	5.44	35
Average	120.2		351	24.9		95	24.4		74	21.1		58	23.2		59	10.6		23	7.1		13	0.6		1	2.5		4	0. 2		0.3	0	0	3.30	18
56, tree No. 23-86-9, Valencia strain:																																		
Orchard grade—																																		
1912	76	10	167	0	9	2	2	4	7	7	0	19	23	3	55	13	7	28	22	7	43	2	2	4	2	14	5	2	12	4	0	0	.67	....
1913	76	4	257	31	6	127	23	1	73	9	10	27	10	6	26	1	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
1914	101	3	271	32	14	104	27	11	74	23	6	56	15	6	33	1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1915	133	14	380	5	12	23	16	2	54	38	3	114	53	0	142	16	2	37	4	11	10	0	0	0	0	0	0	0	0	0	0	0	4.00	....
Average	97.0		269	17.6		64	17.3		52	19.5		54	25.5		64	8.3		18	6.8		13	0.5		1	0.7		1	0.7		1	0	0	2.75	....
Standard grade—																																		
1912	33	0	73	1	5	5	1	6	4	3	13	10	10	12	24	6	3	13	5	13	11	0	0	0	3	12	6	0	0	0	0	0	3.00	....
1913	23	6	102	21	0	95	1	8	5	0	6	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1914	7	2	23	3	2	13	0	15	3	0	12	2	1	5	3	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1915	16	12	58	7	12	30	6	4	20	2	6	7	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
Average	20.1		64	8.3		36	2.5		8	1.8		5	3.2		7	1.8		4	1.5		3	0		0	0.9		2	0		0	0	0	3.83	....
Cull fruits—																																		
1912	1	12	24																														1.00	....
1913	3	6	45																														2.00	....
1914	1	8	9																														3.33	....
1915	2	1	11																														5.33	....
Average	2.2		22																														2.92	....

TABLE I. *Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
56, tree No. 23-86-9, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	111 6	264	1 14	7	3 10	11	10 13	29	33 15	79	19 10	41	28 4	54	2 2	4	6 10	11	2 12	4	0 0	0	1.56	4
1913	103 0	401	52 6	222	24 9	78	10 0	28	10 14	27	1 13	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.67	2
1914	109 13	303	36 0	117	28 10	77	24 2	58	16 11	36	2 14	6	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.56	12
1915	152 11	449	13 8	53	22 6	74	40 9	121	53 6	143	16 2	37	4 11	10	0 0	0	0 0	0	0 0	0	0 0	0	4.89	12
Average	119.3	355	25.9	100	19.8	60	21.4	59	28.7	71	10.1	22	8.2	16	0.5	1	1.7	3	0.7	1	0	0	3.17	8
57, tree No. 23-89-9, Valencia strain:																								
Orchard grade—																								
1912	49 3	94	0 4	1	0 5	1	0 12	2	5 10	13	7 8	16	16 8	32	1 10	3	8 13	15	7 13	11	0 0	0	1.67	....
1913	88 8	307	39 9	166	23 8	74	15 15	44	7 12	19	1 12	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	96 0	280	29 1	92	31 11	85	17 10	66	14 0	30	3 10	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	88 10	260	3 3	12	10 10	34	12 0	63	42 0	106	14 9	3	3 11	8	1 14	3	0 11	1	0 0	0	0 0	0	1.33	....
Average	80.6	235	18.0	68	16.5	49	11.6	44	17.3	42	6.9	8	5.1	10	0.9	2	2.4	4	2.0	3	0	0	2.08	....
Standard grade—																								
1912	34 12	68	0 4	1	0 10	2	2 10	7	5 11	13	4 12	10	10 5	19	0 0	0	10 8	16	0 0	0	0 0	0	0	....
1913	24 0	108	19 4	93	3 6	11	1 6	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1914	16 12	54	7 6	29	5 8	16	0 12	2	2 10	6	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	53 6	161	5 10	24	15 15	53	15 15	46	8 12	22	7 2	16	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
Average	32.2	98	8.1	37	6.4	21	5.2	15	4.3	10	3.1	7	2.6	5	0	0	2.6	4	0	0	0	0	2.42	....
Cull fruits—																								
1912	13 14	25	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.33	....
1913	7 0	116	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3.00	....
1914	2 4	11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2.00	....
1915	1 10	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3.33	....
Average	6.2	40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2.17	....

Total crop:																												
1912	97	13	187	0	8	2	0	15	3	3	6	9	11	5	26	12	4	26	26	13	51	1	10	3	19	5	31	7	13	11	0	0	0	.67	3
1913	119	8	531	58	13	259	26	14	85	17	5	48	7	12	19	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	1
1914	115	0	345	36	7	121	37	3	101	18	6	68	16	10	36	4	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.56	11
1915	143	10	427	8	13	36	26	9	87	27	15	109	50	12	128	21	11	49	3	11	8	1	14	3	0	11	1	0	0	0	0	0	0	3.00	21
Average	**119**	**0**	**373**	**26**	**1**	**105**	**22**	**9**	**69**	**16**	**8**	**59**	**21**	**6**	**52**	**10**	**0**	**22**	**7**	**6**	**15**	**0**	**9**	**2**	**5**	**0**	**8**	**2**	**0**	**3**	**0**	**0**	**0**	2.23	**9**
58, tree No. 23-88-4, Valencia strain:																																			
Orchard grade—																																			
1912	75	3	168	1	4	5	4	14	15	6	9	20	15	12	39	12	8	27	21	7	41	1	10	3	9	1	15	2	2	3	0	0	0	1.00	....
1913	62	8	199	21	15	86	18	14	59	6	12	19	10	9	26	2	13	6	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1914	116	11	334	39	2	131	36	15	101	30	6	76	9	4	21	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	86	13	237	2	11	13	8	6	27	20	12	60	36	12	95	13	4	31	5	0	11	0	0	0	0	0	0	0	0	0	0	0	0	6.67	....
Average	85	3	235	16	3	59	17	3	51	16	1	44	18	1	45	7	4	17	7	0	14	0	4	1	2	3	4	0	5	1	0	0	0	3.50	....
Standard grade—																																			
1912	36	13	78	1	12	6	2	12	8	2	3	6	3	7	8	6	0	12	14	11	28	1	2	2	4	14	8	0	0	0	0	0	0	.33	....
1913	22	12	100	18	10	88	2	8	8	1	2	3	0	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1914	15	2	48	6	2	24	3	0	9	3	0	8	2	0	5	0	8	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	37	9	115	3	6	15	11	6	37	13	12	40	6	13	18	1	12	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
Average	28	1	85	7	5	33	4	9	16	5	0	14	3	1	8	2	1	4	4	1	8	0	3	0	5	1	2	2	0	0	0	0	0	3.08	....
Cull fruits—																																			
1912	10	0	24	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.67	....
1913	7	9	67	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.00	....
1914	3	0	11	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.67	....
1915	0	15	7	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	3.33	....
Average	5	4	27	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.67	....
Total crop—																																			
1912	122	0	270	3	0	11	7	10	23	8	12	26	19	3	47	18	8	39	36	2	69	2	12	5	13	15	23	2	2	3	0	0	0	1.00	9
1913	92	13	366	40	9	174	21	6	67	7	14	22	10	9	26	2	13	6	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	2.56	0
1914	134	13	393	45	4	155	39	15	113	33	6	84	11	4	26	1	8	3	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.00	44
1915	125	5	359	6	1	28	19	12	64	34	8	100	43	9	113	15	0	35	5	8	12	0	0	0	0	0	0	0	0	0	0	0	0	4.78	20
Average	**118**	**7**	**347**	**23**	**7**	**92**	**22**	**2**	**67**	**21**	**1**	**58**	**21**	**1**	**53**	**9**	**5**	**21**	**11**	**1**	**22**	**0**	**7**	**1**	**3**	**5**	**6**	**0**	**5**	**1**	**0**	**0**	**0**	2.84	**18**
59, tree No. 23-88-9, Valencia strain:																																			
Orchard grade—																																			
1912	78	7	180	1	2	4	8	1	25	6	6	17	18	5	47	14	8	31	21	12	42	1	10	3	4	12	8	1	15	3	0	0	0	2.67	....
1913	85	15	306	42	6	176	27	4	87	9	9	27	4	14	12	1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	86	6	235	21	14	72	34	11	94	19	12	48	7	7	16	2	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	97	13	260	4	10	17	10	12	34	19	0	55	42	8	109	10	3	23	8	1	17	2	11	5	0	0	0	0	0	0	0	0	0	5.00	....
Average	87	1	245	17	5	67	20	2	60	13	7	37	18	3	46	7	3	16	7	5	15	1	1	2	1	2	2	0	5	1	0	0	0	3.17	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
59, tree No. 23-88-9, Valencia strain—Continued—																								
Standard grade—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	35 5	79	1 14	7	2 6	7	2 4	6	5 2	12	5 0	11	15 3	29	1 2	3	2 6	4	0 0	0	0 0	0	0.67	....
1913	21 2	121	20 6	109	1 11	6	1 9	5	0 0	0	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.33	....
1914	22 8	67	9 0	33	5 8	16	3 8	9	2 4	5	0 8	1	1 2	2	0 0	0	0 10	1	0 0	0	0 0	0	6.00	....
1915	29 8	90	1 9	17	12 6	40	5 9	16	6 1	15	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	7.00	....
Average	27.9	89	9.0	42	5.5	17	3.2	9	3.4	8	1.7	4	4.1	8	0.3	1	0.8	1	0	0	0	0	5.00	....
Cull fruits—																								
1912	8 14	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	....
1913	3 11	57	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.33	....
1914	1 7	8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.00	....
1915	0 12	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.33	....
Average	3.7	24	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3.17	....
Total crop—																								
1912	122 10	282	3 0	11	10 7	32	8 10	23	23 7	59	19 8	42	36 15	71	2 12	6	7 2	12	1 15	3	0 0	0	1.11	13
1913	113 12	484	62 12	285	28 15	93	11 2	32	4 14	12	2 6	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	9
1914	110 5	340	30 14	105	40 3	110	23 4	57	9 11	21	3 2	6	1 2	2	0 0	0	0 10	1	0 0	0	0 0	0	4.22	43
1915	128 1	356	9 3	34	23 2	74	24 9	71	48 9	124	11 2	25	8 1	17	2 11	5	0 0	0	0 0	0	0 0	0	5.44	11
Average	118.7	358	26.5	109	27.7	77	16.9	46	21.6	54	9.0	20	11.5	23	1.4	3	1.9	3	0.5	1	0	0	3.78	19
60, tree No. 23-92 2, Valencia strain:																								
Orchard grade—																								
1912	37 6	76	0 4	1	0 10	2	2 10	7	5 6	13	5 6	12	8 11	17	3 5	6	6 8	11	4 10	7	0 0	0	2.33	....
1913	58 6	200	22 6	94	15 12	51	11 1	32	6 10	17	2 1	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1914	104 4	333	55 0	198	50 4	87	14 0	36	4 0	10	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1915	73 1	214	6 10	24	15 12	51	17 10	53	27 0	72	5 3	12	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	6.00	....
Average	68.3	206	21.1	79	20.6	48	11.3	32	10.8	28	3.4	8	2.5	5	0.8	2	1.6	3	1.2	2	0	0	4.42	....

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TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
61, tree No. 23-77-20, Valencia strain—Continued.																								
Total crop—	*Lbs.oz.*		*Lbs oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	96 4	196	0 4	1	1 9	5	4 12	13	11 9	30	15 0	33	25 11	50	3 2	6	19 2	32	6 9	10	0 0	0	0.78	0
1913	110 0	446	49 10	216	32 7	111	11 5	34	10 9	29	1 10	4	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	4.44	3
1914	153 12	341	89 9	172	24 6	70	21 15	55	10 8	24	3 0	6	2 2	4	0 0	0	0 0	0	0 0	0	0 0	0	3.89	33
1915	111 1	343	10 5	40	28 10	95	29 8	87	31 7	82	4 12	11	2 8	5	0 9	1	0 0	0	0 0	0	0 0	0	4.56	20
Average	117.8	332	37.4	107	21.8	70	16.9	47	16.0	41	6.1	14	7.7	15	0.9	2	4.8	8	1.6	3	0	0	3.42	14
62, tree No. 23-89-10, Valencia strain:																								
Orchard grade—																								
1912	32 12	69	0 4	1	1 6	4	2 4	6	6 12	17	4 11	10	7 1	14	3 6	6	3 0	5	4 0	6	0 0	0	.67	....
1913	100 7	319	27 0	109	36 7	114	17 10	49	14 4	36	4 2	9	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1914	93 2	249	23 2	73	32 4	88	22 10	55	15 2	33	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	78 14	196	0 0	0	2 5	7	11 4	32	36 12	94	17 9	40	8 14	19	2 2	4	0 0	0	0 0	0	0 0	0	8.00	....
Average	76.3	208	12.6	46	18.1	53	13.4	36	18.2	45	6.6	15	4.2	9	1.4	3	0.8	1	1.0	2	0	0	3.84	....
Standard grade—																								
1912	68 6	148	4 0	14	2 1	6	5 14	16	12 13	30	14 14	31	12 11	24	2 10	5	13 7	22	0 0	0	0 0	0	.67	....
1913	28 10	124	21 12	102	6 3	20	0 5	1	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
1914	12 9	38	4 8	18	2 6	7	2 0	5	2 2	5	1 0	2	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	6.67	....
1915	33 0	93	1 4	6	7 4	23	9 9	27	10 10	27	3 6	8	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
Average	35.6	101	7.9	35	4.5	14	4.4	12	6.5	16	4.8	10	3.5	7	0.7	1	3.4	6	0	0	0	0	4.17	....
Cull fruits—																								
1912	8 8	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1913	5 0	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
1914	1 4	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1915	1 0	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.00	....
Average	3.9	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.17	....

Total crop—																														
1912	109	10	234	4	4	15	3	7	10	8	2	22	19	9	47	19	9	41	19	12	38	6	0	11	16	7	27	4	0	6	0	0	0	1.11	0
1913	134	1	523	48	12	211	42	10	134	17	15	50	14	10	37	4	2	9	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3.89	2
1914	106	15	297	27	10	91	34	10	95	24	10	60	17	4	38	1	0	2	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	4.22	3
1915	112	14	295	1	4	6	9	9	30	20	13	59	47	6	121	20	15	48	9	13	21	2	2	4	0	0	0	0	0	0	0	0	0	5.67	3
Average	**115.9**		**337**	**20.5**		**81**	**22.6**		**67**	**17.9**		**48**	**24.7**		**61**	**11.4**		**25**	**7.8**		**16**	**2.0**		**4**	**4.1**		**7**	**1.0**		**2**	**0**		**0**	**3.72**	**2**
63, tree No. 23–76–20, Sporting strain:																																			
Orchard grade—																																			
1912	49	4	95	0	0	0	1	6	4	1	14	5	5	0	12	7	14	17	15	5	29	2	6	4	10	7	17	5	0	7	0	0	0	.67	....
1913	92	12	298	26	6	104	28	1	91	18	13	54	15	8	40	3	7	8	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1914	90	12	254	30	3	99	29	7	81	21	1	52	8	8	19	1	0	2	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	92	9	247	5	5	19	13	15	43	18	14	54	37	10	94	13	5	30	2	15	6	0	9	1	0	0	0	0	0	0	0	0	0	5.67	....
Average	81.3		224	15.5		56	18.2		55	15.2		41	16.7		41	6.4		14	4.8		9	0.7		1	2.6		4	1.3		2	0		0	3.42	....
Standard grade—																																			
1912	26	3	52	0	15	3	0	0	0	2	0	5	2	2	5	4	7	9	10	11	20	2	4	4	3	12	6	0	0	0	0	0	0	.67	....
1913	22	6	98	16	5	80	3	2	10	1	6	4	1	3	3	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1914	32	12	106	13	15	53	11	8	34	4	6	12	2	7	6	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	35	10	117	6	8	31	12	5	41	9	3	27	4	11	12	2	5	5	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	4.33	....
Average	29.2		93	9.4		42	6.7		21	4.2		12	2.6		7	1.9		4	2.7		5	0.7		1	0.9		2	0		0	0		0	2.59	....
Cull fruits—																																			
1912	12	9	24	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.33	....
1913	3	15	36	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.00	....
1914	1	0	7	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.33	....
1915	3	8	16	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	4.67	....
Average	5.3		21	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.58	....
Total crop—																																			
1912	88	0	171	0	15	3	1	6	4	3	14	10	7	2	17	12	5	26	26	0	49	4	10	8	14	3	23	5	0	7	0	0	0	.89	0
1913	119	1	432	42	11	184	31	3	101	20	3	58	26	11	43	3	13	9	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	3.11	5
1914	124	8	367	44	2	152	40	15	115	25	7	64	10	15	25	1	8	3	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	3.22	16
1915	131	11	380	11	13	50	26	4	84	28	1	81	42	5	106	15	10	35	2	15	6	1	3	2	0	0	0	0	0	0	0	0	0	4.89	27
Average	**115.8**		**338**	**24.6**		**97**	**24.9**		**76**	**19.4**		**53**	**21.8**		**48**	**8.3**		**18**	**7.5**		**14**	**1.5**		**2**	**3.5**		**6**	**1.3**		**2**	**0**		**0**	**3.03**	**12**
64, tree No. 23–93–6, Valencia strain:																																			
Orchard grade—																																			
1912	61	15	121	0	0	0	2	7	7	2	4	6	5	0	12	9	7	20	23	11	46	4	2	7	10	0	16	5	0	7	0	0	0	1.67	....
1913	77	7	254	26	6	107	24	14	80	11	15	33	10	6	26	3	5	7	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1914	97	7	290	48	2	160	32	1	88	12	14	32	3	14	9	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	97	15	306	20	11	78	28	13	94	24	2	70	21	8	57	2	6	6	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
Average	83.7		243	23.8		86	22.1		67	12.8		35	10.2		26	3.9		9	6.2		12	1.0		2	2.5		4	1.3		2	0		0	3.42	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
64, tree No. 23-93-6, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	38 15	78	0 0	0	2 2	6	3 8	9	4 11	11	6 0	12	16 8	30	1 4	2	4 14	8	0 0	0	0 0	0	0.33	....
1913	19 8	92	15 15	81	2 7	8	1 2	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1914	16 5	59	13 12	52	1 6	4	1 3	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	36 5	131	12 12	55	16 4	55	5 8	16	1 6	4	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
Average	27.8	90	10.6	47	5.5	18	2.8	8	1.5	4	1.6	3	4.1	8	0.3	0.5	1.2	2	0	0	0	0	2.92	....
Cull fruits—																								
1912	6 4	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	....
1913	4 2	70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.67	....
1914	2 0	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00	....
1915	5 0	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.00	....
Average	4.3	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.42	....
Total crop—																								
1912	107 2	212	0 0	0	4 9	13	5 12	15	9 11	23	15 7	32	40 3	76	5 6	9	14 14	24	5 0	7	0 0	0	1.00	0
1913	101 2	416	42 5	188	27 5	88	13 1	36	10 6	26	3 5	7	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	4.22	1
1914	115 12	367	61 14	212	33 7	92	14 1	35	3 14	9	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	2
1915	139 4	468	33 7	133	45 1	149	29 10	86	22 14	61	2 13	7	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	4.44	3
Average	**115.8**	**366**	**34.4**	**133**	**27.6**	**86**	**15.6**	**43**	**11.7**	**30**	**5.5**	**12**	**10.3**	**20**	**1.3**	**2**	**3.7**	**6**	**1.3**	**2**	**0**	**0**	**3.25**	**2**
65, tree No. 23-87-10, Coarse strain:																								
Orchard grade—																								
1912	59 14	127	0 8	2	1 10	5	2 7	7	8 12	22	14 5	32	16 10	33	2 12	5	8 12	15	4 2	6	0 0	0	.67	....
1913	106 10	385	39 8	168	31 0	119	16 14	49	15 6	40	3 14	9	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1914	75 5	185	6 10	21	15 8	42	21 15	54	24 10	55	6 1	12	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	1.00	....
1915	68 1	166	0 4	1	1 4	4	6 11	19	31 1	79	15 5	35	9 14	21	3 10	7	0 0	0	0 0	0	0 0	0	4.00	....
Average	77.5	216	11.7	48	12.3	43	12.0	32	20.0	49	9.9	22	6.5	14	1.6	3	2.2	4	1.0	2	0	0	2.59	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
66, tree No. 23-76-21, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	82 5	143	0 4	1	0 6	1	1 13	5	11 1	26	11 3	24	21 5	38	1 12	3	16 14	27	7 9	11	0 0	0	0.89	2
1913	120 4	476	56 5	240	40 1	132	11 5	33	8 4	22	0 7	1	0 12	2	0 0	0	0 0	0	0 0	0	0 0	0	3.56	0
1914	129 11	358	29 0	99	37 4	104	34 8	87	22 1	50	6 6	13	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.11	17
1915	127 10	383	16 5	63	33 12	109	27 2	78	33 14	87	11 9	26	3 6	7	0 0	0	0 0	0	0 0	0	0 0	0	3.89	14
Average	**115.0**	**340**	**25.2**	**101**	**27.9**	**87**	**18.7**	**51**	**18.8**	**46**	**7.4**	**16**	**6.4**	**12**	**0.4**	**1**	**4.2**	**7**	**1.9**	**3**	**0**	**0**	**2.61**	**8**
67, tree No. 23-89-1, Rough strain:																								
Orchard grade—																								
1912	47 3	108	0 13	3	3 6	10	3 3	9	13 14	34	12 6	26	9 3	18	2 1	4	2 5	4	0 0	0	0 0	0	.33	....
1913	54 4	189	27 5	108	18 0	57	5 4	15	2 11	7	0 8	1	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1914	47 0	145	27 12	94	13 10	37	3 8	9	2 2	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.67	....
1915	32 3	86	1 1	4	3 14	12	7 4	21	12 13	33	5 11	13	1 8	3	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
Average	45.2	132	14.2	52	9.7	29	4.8	14	7.9	20	4.6	10	2.8	6	0.5	1	0.6	1	0	0	0	0	3.67	....
Standard grade—																								
1912	85 15	187	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1913	37 13	158	31 9	140	4 5	13	1 7	4	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.67	....
1914	79 2	253	36 2	135	22 3	66	11 7	30	8 0	19	1 6	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	63 2	185	2 12	11	20 10	68	21 2	60	11 0	28	7 10	18	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
Average	66.5	196	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.50	....
Cull fruits—																								
1912	0 0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	6 7	69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.33	....
1914	1 5	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.33	....
1915	3 6	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
Average	2.8	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.83	....

Total crop—																												
1912	133	2	295																							.67	164
1913	98	8	416	58	14	248	22	5	70	6	11	19	3	3	8	0	8	1	0	8	1	0	0	0	0	0	0	0	0	0	0	4.00	371
1914	127	7	408	63	14	229	35	13	103	14	15	39	10	2	24	1	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4.78	240
1915	98	11	285	3	13	15	24	8	80	28	6	81	23	13	61	13	5	31	1	8	3	0	0	0	0	0	0	0	0	0	0	3.89	178
Average	**114.4**		**351**																							**3.33**	**238**
68, tree No. 27–82–18, Smooth strain:																												
Orchard grade—																												
1912	136	12	281	2	11	10	6	9	20	2	10	8	19	1	48	22	5	49	35	2	69	5	11	10	30	8	50	12	3	17	0	0	0	.33	....
1913	93	1	249	7	11	30	16	14	54	15	10	43	31	6	78	12	0	26	6	11	13	1	9	3	1	4	2	0	0	0	0	0	0	2.00	....
1914	109	1	303	24	8	79	38	14	110	34	6	88	10	14	25	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	36	13	82	0	0	0	0	0	0	1	13	5	13	13	33	11	14	26	8	3	16	1	2	2	0	0	0	0	0	0	0	0	0	4.67	....
Average	93.9		229	8.7		30	15.6		46	13.6		36	18.8		46	11.7		26	12.5		25	2.1		4	7.9		13	3.1		4	0		0	3.00	....
Standard grade—																												
1912	5	7	12	0	4	1	0	0	0	0	12	2	0	7	1	1	7	3	2	9	5	0	0	0	0	0	0	0	0	0	0	0	0	1.00	....
1913	26	6	101	13	10	61	6	11	23	3	8	11	2	1	5	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.67	....
1914	24	12	80	9	2	35	7	0	22	3	14	11	4	5	11	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	8	4	20	1	0	3	1	2	3	3	3	8	1	14	4	0	0	0	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	3.33	....
Average	16.2		53	6.0		25	3.7		12	2.8		8	2.2		5	0.6		1	0.8		2	0.1		0.3	0		0	0		0	0		0	2.16	....
Cull fruits—																												
1912	7	4	17																															.33	....
1913	4	4	56																															1.00	....
1914	2	14	16																															4.00	....
1915	0	0	0																															(*a*)	....
Average	3.6		22																															1.78	....
Total crop—																												
1912	149	7	310	2	15	11	6	9	20	3	6	10	19	8	49	23	12	52	37	11	74	5	11	10	30	8	50	12	3	17	0	0	0	.56	0
1913	123	11	406	21	5	91	23	9	77	19	2	54	33	7	83	12	8	27	6	11	13	1	9	3	1	4	2	0	0	0	0	0	0	1.63	1
1914	136	11	399	33	10	114	45	14	132	38	4	99	15	3	36	0	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.89	2
1915	45	1	102	1	0	3	1	2	3	5	0	13	15	11	37	11	14	26	8	11	17	1	11	3	0	0	0	0	0	0	0	0	0	4.00	0
Average	**113.7**		**304**	**14.7**		**55**	**19.3**		**58**	**16.4**		**44**	**21.0**		**51**	**12.3**		**27**	**13.3**		**26**	**2.2**		**4**	**7.9**		**13**	**3.1**		**4**	**0**		**0**	**2.41**	**0.8**
69, tree No. 23–87–3, Valencia strain:																												
Orchard grade—																												
1912	60	6	116	0	14	1	1	15	6	2	10	7	8	12	20	10	5	21	17	0	32	4	14	8	6	14	11	7	2	10	0	0	0	.33	....
1913	89	10	312	41	13	177	22	2	70	10	15	30	10	13	27	1	12	4	2	3	4	0	0	0	0	0	0	0	0	0	0	0	0	1.67	....
1914	67	1	178	22	0	70	20	3	52	15	2	36	7	12	16	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1915	88	7	232	3	15	14	9	13	31	19	12	56	35	11	90	11	13	26	6	14	14	0	9	1	0	0	0	0	0	0	0	0	0	4.33	....
Average	76.4		210	17.1		66	13.5		40	12.1		32	15.8		38	6.5		14	6.5		13	1.4		2	1.7		3	1.8		3	0		0	2.75	....

a No count was made to determine the seed content of the fruits in this group.

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
69, tree No. 23–87–3, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	37 7	74	1 8	5	1 6	4	1 15	5	6 3	14	7 3	14	9 11	17	0 9	1	9 0	14	0 0	0	0 0	0	0.33	....
1913	24 12	106	20 4	93	1 14	6	1 0	3	1 4	3	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1914	29 0	83	8 12	30	10 5	29	4 11	12	3 6	8	1 14	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	31 13	100	6 10	26	14 2	46	5 6	15	3 5	8	1 6	3	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
Average	30.8	91	9.3	39	6.9	21	3.3	9	3.5	8	2.7	6	2.7	5	0.1	0.3	2.3	4	0	0	0	0	2.58	....
Cull fruits—																								
1912	13 1	25																					1.33	....
1913	3 2	35																					1.33	....
1914	3 4	16																					1.33	....
1915	3 7	7																					4.00	....
Average	5.7	21																					2.00	....
Total crop—																								
1912	110 14	215	2 6	6	3 5	10	4 9	12	14 15	34	17 8	35	26 11	49	5 7	9	15 14	25	7 2	10	0 0	0	.67	19
1913	117 8	453	62 1	270	24 0	76	11 15	33	12 1	30	2 2	50	2 3	4	0 0	0	0 0	0	0 0	0	0 0	0	2.11	7
1914	99 5	277	30 12	100	30 8	81	19 13	48	11 2	24	3 14	8	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.11	36
1915	123 11	339	10 9	40	23 15	77	25 2	71	39 0	98	13 3	29	7 14	16	0 9	1	0 0	0	0 0	0	0 0	0	3.78	30
Average	**112.8**	**321**	**26.4**	**104**	**20.4**	**61**	**14.4**	**41**	**19.3**	**47**	**9.2**	**31**	**9.2**	**17**	**1.5**	**3**	**4.0**	**6**	**1.8**	**3**	**0**	**0**	**2.44**	**23**
70, tree No. 23–85–9, Valencia strain:																								
Orchard grade—																								
1912	76 3	168	0 12	3	2 8	7	5 7	15	21 8	51	19 0	41	21 2	41	2 12	5	2 8	4	0 10	1	0 0	0	0	....
1913	71 0	231	21 8	93	17 15	58	9 2	26	17 13	44	3 1	7	1 9	3	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1914	104 6	285	38 6	118	37 13	102	18 3	44	5 13	13	3 11	7	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	94 11	264	4 14	19	8 10	29	24 9	75	36 15	97	13 2	30	5 7	12	1 2	2	0 0	0	0 0	0	0 0	0	6.67	....
Average	86.7	237	16.4	58	16.7	49	14.4	40	20.5	51	9.7	21	7.2	14	1.0	2	0.6	1	0.2	0.3	0	0	3.08	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
71, tree No. 23-91-10, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	145 8	355	2 10	10	13 9	41	20 14	57	44 4	108	25 12	57	23 0	45	2 4	4	2 7	4	0 0	0	0 0	0	0.56	1
1913	67 13	310	34 14	149	15 6	50	5 5	15	4 9	12	2 12	6	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.56	0
1914	139 13	479	100 4	362	29 11	87	6 10	17	1 10	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	4
1915	92 5	227	1 1	3	7 10	22	17 1	47	35 15	89	19 7	43	7 14	16	2 5	4	0 10	1	0 0	0	0 0	0	5.25	1
Average	111.4	343	34.7	131	16.6	50	12.5	34	21.6	53	12.0	27	7.7	15	1.1	2	0.8	1	0	0	0	0	3.71	2
72, tree No. 23-90-3, Valencia strain:																								
Orchard grade—																								
1912	95 8	220	3 14	14	7 15	24	9 2	25	26 2	63	19 7	42	17 12	34	1 13	3	8 12	14	0 11	1	0 0	0	0	....
1913	86 12	299	45 0	176	29 8	91	6 5	18	4 9	11	0 14	2	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1914	86 0	256	45 6	153	21 2	57	13 0	32	6 0	13	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	49 7	131	2 13	9	6 2	19	9 14	28	21 2	54	7 1	16	2 7	5	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
Average	79.4	227	24.3	88	16.2	48	9.6	26	14.5	35	7.0	15	5.2	10	0.5	1	2.2	4	0.2	0.3	0	0	2.67	....
Standard grade—																								
1912	54 7	126	6 0	22	4 12	14	6 2	16	9 13	23	7 7	15	13 2	24	1 1	2	6 2	10	0 0	0	0 0	0	0	....
1913	20 4	92	18 6	86	1 9	5	0 5	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1914	7 11	28	5 14	23	1 0	3	0 6	1	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	29 1	90	4 1	16	11 14	38	9 9	27	2 11	7	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
Average	27.9	84	8.6	37	4.8	15	4.1	11	3.2	8	2.1	4	3.3	6	0.3	0.5	1.6	3	0	0	0	0	2.66	....
Cull fruits—																								
1912	4 7	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.33	....
1913	3 6	51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.67	....
1914	1 12	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1915	1 13	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.67	....
Average	2.8	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.09	....

Total crop—																														
1912	154	6	356	9	14	36	12	11	38	15	4	41	35	15	86	26	14	57	30	14	58	2	14	5	14	14	24	0	11	1	0	0	0	.11	1
1913	110	6	442	63	6	262	31	1	96	6	10	19	4	9	11	0	14	2	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.33	3
1914	95	7	293	51	4	176	22	2	60	13	6	33	6	7	14	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	19
1915	80	5	229	6	14	25	18	0	57	19	7	55	23	13	61	7	15	18	2	7	5	0	0	0	0	0	0	0	0	0	0	0	0	5.11	13
Average	**110.1**		**330**	**32.8**		**125**	**21.0**		**63**	**13.7**		**37**	**17.7**		**43**	**9.1**		**20**	**8.5**		**16**	**0.7**		**1**	**3.7**		**6**	**0.2**		**0.3**	**0**		**0**	**2.81**	**9**
73, tree No. 23-91-4, Valencia strain:																														
Orchard grade—																														
1912	93	3	221	1	15	7	7	10	24	8	7	24	27	11	68	19	9	43	24	1	48	2	2	4	1	12	3	0	0	0	0	0	0	1.00	....
1913	42	15	137	9	3	38	15	11	51	7	12	23	7	12	20	1	0	2	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1914	123	9	418	85	5	307	32	0	94	5	8	15	0	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1915	76	5	232	15	3	56	17	4	56	16	5	48	23	14	63	3	11	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.00	....
Average	84	0	252	27.9		102	18.1		56	9.5		28	15.0		38	6.1		14	6.4		13	0.5		1	0.4		1	0		0	0		0	4.50	....
Standard grade—																														
1912	26	5	60	2	2	7	0	15	3	4	11	13	1	10	4	5	11	12	7	5	14	1	11	3	2	4	4	0	0	0	0	0	0	.33	....
1913	15	12	66	10	13	50	3	14	13	0	11	2	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1914	8	13	41	8	13	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1915	37	0	138	19	6	80	14	4	48	2	10	8	0	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.33	....
Average	22.0		76	10.3		45	4.8		16	2.0		6	0.7		2	1.4		3	1.8		4	0.4		1	0.6		1	0		0	0		0	5.00	....
Cull fruits—																														
1912	2	7	8	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	3.00	....
1913	2	7	42	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	3.67	....
1914	2	0	12	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	4.67	....
1915	2	0	11	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	5.67	....
Average	2.2		18	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	3.92	....
Total crop—																														
1912	121	15	289	4	1	14	8	9	27	13	2	37	29	5	72	25	4	55	31	6	62	3	13	7	4	0	7	0	0	0	0	0	0	1.44	0
1913	61	2	245	20	0	88	19	9	64	8	7	25	8	2	21	1	0	2	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	4.44	0
1914	134	6	471	94	2	348	32	0	94	5	8	15	0	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.78	3
1915	115	5	381	34	9	136	31	8	104	18	15	56	24	10	65	3	11	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.67	0
Average	**108.2**		**346**	**38.2**		**147**	**22.9**		**72**	**11.5**		**33**	**15.7**		**40**	**7.5**		**17**	**8.2**		**16**	**1.0**		**2**	**1.0**		**2**	**0**		**0**	**0**		**0**	**4.58**	**0.8**
74, tree No. 27-82-14, Long strain:																														
Orchard grade—																														
1912	144	9	330	7	10	26	20	0	55	18	10	47	41	3	92	29	7	60	22	15	42	2	6	4	1	12	3	0	10	1	0	0	0	.33	....
1913	103	5	321	45	13	171	28	13	84	9	15	25	15	2	34	2	0	4	1	10	3	0	0	0	0	0	0	0	0	0	0	0	0	1.00	....
1914	2	5	6	0	0	0	1	2	3	0	6	1	0	6	1	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	15	15	40	0	9	2	3	0	9	2	5	6	7	12	18	1	13	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	1.33	....
Average	66.5		174	13.5		50	13.2		38	7.8		20	16.1		36	8.4		17	6.3		12	0.6		1	0.4		1	0.2		0.3	0		0	1.58	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
74, tree No. 27-82-14, Long strain—Continued.																								
Standard grade—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	39 0	91	4 8	16	3 3	9	4 8	12	12 7	28	5 11	11	7 7	13	0 0	0	1 4	2	0 0	0	0 0	0	0.33	....
1913	24 9	101	18 14	85	4 3	12	1 2	3	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1914	75 15	226	39 2	128	28 8	78	4 8	11	2 15	7	0 7	1	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	1.33	....
1915	3 13	10	0 9	2	0 15	3	0 7	1	1 6	3	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
Average	35.8	107	15.8	58	9.2	26	2.6	7	4.3	10	1.7	3	2.0	4	0	0	0.3	0.5	0	0	0	0	1.75	....
Cull fruits—																								
1912	12 13	34																					0	....
1913	3 15	67																					1.00	....
1914	1 11	6																					2.33	....
1915	1 1	3																					1.67	....
Average	4.9	28																					1.25	....
Total crop—																								
1912	196 6	455	12 2	42	23 3	64	23 2	59	53 10	120	35 2	71	30 6	55	2 6	4	3 0	5	0 10	1	0 0	0	.22	34
1913	131 13	489	64 11	256	33 0	96	11 1	28	15 8	35	2 0	4	1 10	3	0 0	0	0 0	0	0 0	0	0 0	0	1.44	1
1914	79 15	238	39 2	128	29 10	81	4 14	12	3 5	8	0 14	2	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	2.44	23
1915	20 13	53	1 2	4	3 15	12	2 12	7	9 2	21	2 5	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	2.00	19
Average	**107.2**	**309**	**29.3**	**108**	**22.4**	**63**	**10.5**	**27**	**20.4**	**46**	**10.1**	**21**	**8.2**	**15**	**0.6**	**1**	**0.8**	**1**	**0.2**	**0.3**	**0**	**0**	**1.53**	**19**
75, tree No. 23-77-19, Valencia strain:																								
Orchard grade—																								
1912	83 13	214	3 2	12	14 9	45	11 6	31	28 0	71	13 14	30	10 8	21	1 2	2	1 4	2	0 0	0	0 0	0	1.33	....
1913	97 8	326	31 0	125	36 7	119	17 3	50	10 11	27	2 3	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	66 3	170	11 7	36	19 14	51	26 8	65	7 4	16	1 2	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	88 3	251	9 10	35	19 2	60	20 5	58	30 15	80	5 3	12	2 8	5	0 8	1	0 0	0	0 0	0	0 0	0	4.33	....
Average	83.9	240	13.8	52	22.5	69	18.8	51	19.2	49	5.6	12	3.3	7	0.4	1	0.3	0.5	0	0	0	0	2.75	....

Standard grade—																																			
1912	23	8	59	1	2	4	3	9	11	5	7	15	4	13	12	2	0	4	6	1	12	0	0	0	0	8	1	0	0	0	0	0	2.67	....
1913	16	9	69	12	15	55	2	12	10	0	6	2	0	4	1	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
1914	7	9	20	1	3	4	3	0	9	0	6	1	0	14	2	1	8	3	0	0	0	0	0	0	0	0	0	0	10	1	0	0	6.00	....
1915	32	3	99	6	8	26	8	6	28	9	4	26	4	7	11	3	2	7	0	8	1	0	0	0	0	0	0	0	0	0	0	0	4.67	....
Average	20.0		62	5.4		22	4.4		15	3.9		11	2.6		7	1.7		4	1.6		3	0	0	0	0.3		0.5	0		0	0		4.75	....
Cull fruits—																																		
1912	6	0	15																														2.33	....
1913	2	0	29																														4.67	....
1914	0	8	4																														.67	....
1915	1	10	9																														5.67	....
Average	2.5		14																														3.34	....
Total crop—																																		
1912	113	5	288	4	4	16	18	2	56	16	13	46	32	13	83	15	14	34	16	9	33	1	2	2	1	12	3	0	0	0	0	0	2.11	3
1913	116	1	424	43	15	180	39	3	129	17	9	52	10	15	28	2	7	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.44	11
1914	74	4	194	12	10	40	22	14	60	26	14	66	8	2	18	2	10	5	0	0	0	0	0	0	0	10	1	0	0	0	0	0	3.00	12
1915	122	0	359	16	2	61	27	8	88	29	9	84	35	6	91	8	5	19	3	0	6	0	8	1	0	0	0	0	0	0	0	0	4.89	22
Average	**106.4**		**316**	**19.2**		**74**	**26.9**		**83**	**22.7**		**62**	**21.8**		**55**	**7.3**		**16**	**4.9**		**10**	**0.4**		**1**	**0.6**		**1**	**0**		**0**	**0**		**3.61**	**12**
76, tree No. 27-83-13, Corrugated strain: Orchard grade—																																		
1912	31	6	80	0	12	3	4	4	14	4	6	13	8	13	22	3	13	9	5	10	12	1	8	3	2	4	4	0	0	0	0	0	1.00	....
1913	27	4	80	4	3	16	7	8	24	5	7	15	7	6	19	2	12	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1914	27	2	71	3	7	11	7	6	21	9	11	24	5	11	13	0	7	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1915	15	7	32	0	0	0	0	0	0	0	11	2	2	0	5	2	4	5	6	1	12	3	3	6	1	4	2	0	0	0	0	0	6.33	....
Average	25.3		66	2.1		8	4.8		15	5.0		14	6.0		15	2.3		5	3.0		6	1.2		2	0.9		2	0		0	0		3.92	....
Standard grade—																																		
1912	115	9	268																														0	....
1913	107	5	407																														3.67	....
1914	84	3	235	11	12	43	22	6	68	15	10	42	21	2	52	9	8	22	3	13	8	0	0	0	0	0	0	0	0	0	0	0	1.33	....
1915	10	12	23	0	0	0	0	0	0	0	11	2	1	2	3	3	11	8	3	9	7	1	1	2	0	10	1	0	0	0	0	0	3.67	....
Average	79.5		233																														2.17	....
Cull fruits—																																		
1912	0	0	0																														0	....
1913	3	0	31																														.33	....
1914	1	3	5																														1.33	....
1915	0	0	0																														(a)	....
Average	1.0		9																														.55	....

a No count was made to determine the seed content of the fruits in this group.

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
76, tree No. 27–83–13, Corrugated strain—Continued.																								
Total crop—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	146 15	348	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.33	109
1913	137 9	518	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	203
1914	112 8	311	15 3	54	29 12	89	25 5	66	26 13	65	9 15	23	4 5	9	0 0	0	0 0	0	0 0	0	0 0	0	2.67	115
1915	26 3	55	0 0	0	0 0	0	1 6	4	3 2	8	5 15	13	9 10	19	4 4	8	1 14	3	0 0	0	0 0	0	5.00	40
Average	105.8	308	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.36	117
77, tree No. 23–88–3, Corrugated strain:																								
Orchard grade—																								
1912	19 13	43	0 0	0	0 5	1	1 2	3	2 6	6	5 0	11	8 0	17	0 8	1	1 13	3	0 11	1	0 0	0	1.00	.....
1913	20 10	69	10 0	38	6 6	20	1 6	4	1 15	5	0 15	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	.....
1914	19 12	62	12 4	42	4 11	13	2 6	6	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	.....
1915	19 1	50	0 7	2	1 12	6	2 6	7	6 15	18	6 2	14	0 15	2	0 8	1	0 0	0	0 0	0	0 0	0	4.33	.....
Average	19.8	56	5.7	21	3.3	10	1.8	5	2.9	8	3.0	7	2.2	5	0.3	0.5	0.5	0.8	0.2	0.3	0	0	3.33	.....
Standard grade—																								
1912	124 12	279	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.33	.....
1913	72 14	271	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.00	.....
1914	92 15	310	45 14	175	32 8	97	11 2	30	2 1	5	1 6	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	.....
1915	45 4	129	2 13	11	10 12	35	16 8	47	5 1	13	8 5	19	1 5	3	0 8	1	0 0	0	0 0	0	0 0	0	2.67	.....
Average	84.0	247	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.25	.....
Cull fruits—																								
1912	0 0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....
1913	3 0	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	.....
1914	1 12	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	.....
1915	2 4	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.00	.....
Average	1.8	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	.....

Total crop—																														
1912	144	9	322																								.78	101		
1913	96	8	369																								4.33	161		
1914	114	7	383	58	2	217	37	3	110	13	8	36	2	8	6	1	6	3	0	0	0	0	0	0	0	0	0	0	2.78	116		
1915	66	9	187	3	4	13	12	8	41	18	14	54	12	0	31	14	7	33	2	4	5	1	0	2	0	0	0	0	0	0	4.00	102		
Average	**105.5**		**315**																								**2.97**	**120**		
78, tree No. 23-76-19, Corrugated strain:																														
Orchard grade—																														
1912	18	9	41	0	0	0	1	6	3	1	3	3	4	0	10	3	9	8	5	2	11	1	9	3	1	12	3	0	0	0	0	0	1.67	....		
1913	14	13	44	0	7	2	6	7	21	3	2	9	2	10	7	1	11	4	0	8	1	0	0	0	0	0	0	0	0	0	0	0	5.00	....		
1914	15	6	48	7	8	26	4	6	13	3	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	0	3.00	....		
1915	12	2	29	0	4	1	0	10	2	0	5	1	4	13	12	3	1	7	1	7	3	1	10	3	0	0	0	0	0	0	0	0	3.33	....		
Average	15.2		41	2.0		7	3.2		10	1.9		5	2.9		7	2.1		5	1.8		4	0.8		2	0.4		0.8	0.1		0.3	0	0	0	3.25	....		
Standard grade—																														
1912	108	3	240																														2.67	....		
1913	63	8	206																														4.33	....		
1914	134	7	444	69	4	264	37	5	108	17	10	47	9	8	23	0	6	1	0	6	1	0	0	0	0	0	0	0	0	0	0	0	.67	....		
1915	39	5	95	0	14	4	3	14	13	6	0	17	7	3	18	11	6	25	4	9	9	2	5	4	3	2	5	0	0	0	0	0	2.67	....		
Average	86.4		246																														2.59	....		
Cull fruits—																														
1912	0	0	0																														0	....		
1913	1	14	18																														.33	....		
1914	1	10	11																														2.00	....		
1915	1	3	6																														3.67	....		
Average	1.2		9																														1.50	....		
Total crop—																														
1912	126	12	281																														1.44	49		
1913	80	3	268																														3.00	115		
1914	151	7	503	76	12	290	41	11	121	20	10	55	9	8	23	0	6	1	0	6	1	0	0	0	0	0	0	0	8	1	0	0	1.89	82		
1915	52	10	130	1	2	5	4	8	15	6	5	18	12	0	30	14	7	32	6	0	12	3	15	7	3	2	5	0	0	0	0	0	3.22	64		
Average	**102.8**		**296**																														**2.39**	**78**		
79, tree No. 23-77-16, Corrugated strain:																														
Orchard grade—																														
1912	19	2	36	0	0	0	0	5	1	0	6	1	3	7	1	3	7	8	4	11	8	0	9	1	3	8	6	2	13	4	0	0	0	0	....	
1913	30	5	91	6	8	25	9	10	30	4	8	13	6	13	17	2	4	5	0	10	1	0	0	0	0	0	0	0	0	0	0	0	5.67	....		
1914	38	10	115	14	10	51	12	14	36	8	10	22	2	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....		
1915	12	2	29	0	8	2	0	0	0	2	3	6	3	10	9	2	4	5	3	0	6	0	9	1	0	0	0	0	0	0	0	0	4.00	....		
Average	25.0		68	5.4		20	5.7		17	3.9		11	4.1		8	2.0		5	2.1		4	0.3		0.5	0.9		2	0.7		1	0	0	3.08	....		

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Total.		Sizes. 288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.		Average number of seeds per fruit.	Number of variable fruits.
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
79, tree No. 23-77-16, Corrugated strain—Continued.																								
Standard grade—	*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*		*Lbs.oz.*			
1912	77 15	148	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	63 5	227	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1914	129 8	410	59 12	222	36 5	105	17 9	46	13 2	31	1 14	4	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	1.67	....
1915	34 3	92	2 12	13	4 10	15	6 14	20	7 3	18	8 14	19	3 4	6	0 10	1	0 0	0	0 0	0	0 0	0	2.00	....
Average	76.2	219	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.33	....
Cull fruits—																								
1912	0 0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	2 8	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....
1914	1 6	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1915	1 0	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.00	....
Average	1.2	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.75	....
Total crop—																								
1912	97 1	184	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	72
1913	96 2	345	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.22	170
1914	169 8	538	74 6	273	49 3	141	26 3	68	15 10	37	1 14	4	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	1.67	161
1915	47 5	126	3 4	15	4 10	15	9 1	26	10 13	27	11 2	24	6 4	12	1 3	2	0 0	0	0 0	0	0 0	0	3.33	48
Average	**102.5**	**298**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	**2.06**	**113**
80, tree No. 23-75-21, Valencia strain:																								
Orchard grade—																								
1912	46 11	112	1 2	4	5 3	16	4 13	14	15 4	38	8 7	19	7 6	15	1 8	1	2 6	4	0 10	1	0 0	0	1.00	....
1913	63 2	196	15 10	58	20 4	65	10 4	29	14 5	37	2 3	5	0 8	2	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1914	52 15	148	14 2	46	20 5	57	11 0	28	6 8	15	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.33	....
1915	51 2	119	0 0	0	1 4	4	4 2	12	16 10	42	8 10	20	13 4	28	5 8	10	1 12	3	0 0	0	0 0	0	3.67	....
Average	53.5	144	7.7	27	11.8	36	7.5	21	14.4	33	5.1	12	5.3	11	1.8	3	1.0	2	0.2	0.3	0	0	2.67	....

Standard grade—																																			
1912	63	4	158	3	15	14	7	1	22	9	8	26	14	13	37	8	10	22	11	15	24	3	3	6	4	3	7	0	0	0	0	0	0	.33	....
1913	48	6	178	26	9	112	11	13	39	5	10	16	3	8	9	0	6	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	1.67	....
1914	31	14	97	10	12	40	9	0	28	5	5	14	3	0	7	3	4	7	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	2.00	....
1915	32	12	96	2	14	15	5	6	18	6	14	20	6	15	19	7	11	18	3	0	6	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
Average	44.1		132	11.0		45	8.3		27	6.8		19	7.1		18	5.0		12	3.9		8	0.9		2	1.1		2	0		0	0		0	2.00	....
Cull fruits—																																			
1912	13	2	28																															.33	....
1913	2	4	36																															2.67	....
1914	1	12	7																															2.67	....
1915	0	9	3																															3.00	....
Average	4.4		19																															2.17	....
Total crop—																																			
1912	123	1	298	5	1	18	12	4	38	14	5	40	30	1	75	17	1	41	19	5	39	4	11	7	6	9	11	0	1	10	0	0	0	.56	15
1913	113	12	410	42	3	170	32	1	104	15	14	45	17	13	46	2	9	6	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	.44	22
1914	86	9	252	24	14	86	29	5	85	16	5	42	9	8	22	4	4	9	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	2.33	32
1915	84	7	218	2	14	15	6	10	22	11	0	32	23	9	61	16	5	38	16	4	34	5	8	10	1	12	3	0	0	0	0	0	0	3.89	18
Average	**102.0**		**295**	**18.8**		**72**	**20.1**		**62**	**14.4**		**40**	**20.2**		**51**	**10.1**		**24**	**9.1**		**19**	**2.7**		**5**	**2.1**		**4**	**0.2**	0.3	**0**	**0**	2.56	22
81, tree No. 23–75–18, Valencia strain:																																			
Orchard grade—																																			
1912	59	1	134	0	10	2	2	5	7	2	12	7	15	10	36	10	0	22	15	10	40	4	0	7	5	6	9	2	12	4	0	0	0	3.33	....
1913	64	12	208	21	14	85	19	2	62	13	3	37	6	15	17	1	15	4	1	1	2	0	0	0	0	10	1	0	0	0	0	0	0	6.33	....
1914	76	10	194	12	11	49	16	13	46	24	13	61	17	10	39	2	7	5	2	4	4	0	0	0	0	0	0	0	0	0	0	0	-0	5.00	....
1915	97	3	241	0	8	2	5	0	15	16	8	47	36	15	94	24	6	55	10	11	22	3	3	6	0	0	0	0	0	0	0	0	0	5.67	....
Average	74.4		194	9.1		35	10.8		33	14.3		38	19.2		47	9.7		22	7.4		17	1.8		3	1.5		3	0.7		1	0	0	5.08	....
Standard grade—																																			
1912	25	1	56	0	18	2	1	12	5	2	2	6	6	10	16	3	11	8	7	6	14	1	1	2	1	15	3	0	0	0	0	0	0	1.00	....
1913	20	7	88	15	4	72	3	12	12	1	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.33	....
1914	14	6	40	2	12	10	3	2	9	1	8	4	5	10	14	1	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	22	15	60	0	11	3	3	14	12	6	12	18	5	11	14	5	15	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
Average	20.7		61	5.0		22	3.1		10	3.0		8	4.5		11	2.8		6	1.8		4	0.3		0.5	0.5		1	0		0	0		0	3.33	....
Cull fruits—																																			
1912	16	9	42																															1.67	....
1913	3	9	47																															3.33	....
1914	1	12	7																															5.00	....
1915	1	9	7																															6.33	....
Average	5.9		26																															4.08	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
81, tree No. 23–75–18, Valencia strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	100 11	232	1 2	4	4 1	12	4 14	13	22 4	52	13 11	30	23 0	54	5 1	9	7 5	12	2 12	4	0 0	0	2.00	2
1913	88 12	343	37 2	157	22 14	74	14 10	41	6 15	17	1 15	4	1 1	2	0 0	0	0 10	1	0 0	0	0 0	0	5.00	3
1914	92 12	241	15 7	49	19 15	55	26 5	65	23 4	53	3 13	8	2 4	4	0 0	0	0 0	0	0 0	0	0 0	0	4.22	9
1915	121 11	308	1 3	5	8 14	27	23 4	65	42 10	108	30 5	68	10 11	22	3 3	6	0 0	0	0 0	0	0 0	0	5.44	12
Average	**101. 0**	**281**	**13. 7**	**54**	**13. 9**	**42**	**17. 3**	**46**	**23. 8**	**58**	**12. 4**	**28**	**9. 3**	**21**	**2. 1**	**4**	**2. 0**	**3**	**0. 7**	**1**	**0**	**0**	**4.17**	**7**
82, tree No. 23–85–8, Unproductive strain:																								
Orchard grade—																								
1912	94 12	209	4 0	15	5 13	18	7 2	19	19 3	46	11 12	26	26 2	51	3 6	6	11 14	20	5 8	8	0 0	0	0	....
1913	72 2	218	19 7	81	12 6	40	11 4	32	13 1	33	6 0	13	6 8	13	1 1	2	1 12	3	0 11	1	0 0	0	3.67	....
1914	89 7	246	31 13	105	22 15	63	16 8	40	12 0	26	5 0	10	0 9	1	0 0	0	0 10	1	0 0	0	0 0	0	1.67	....
1915	65 15	164	1 8	6	2 1	7	9 4	28	24 7	63	13 10	31	8 13	18	4 15	9	0 10	1	0 11	1	0 0	0	4.33	....
Average	80. 6	209	14. 2	52	10. 8	32	11. 2	30	17. 2	42	9. 1	20	10. 5	21	2. 3	4	3. 7	6	1. 7	3	0	0	2.42	....
Standard grade—																								
1912	21 4	45	0 5	1	0 6	1	4 2	11	2 15	7	2 6	5	6 5	12	0 9	1	4 4	7	0 0	0	0 0	0	1.33	....
1913	16 8	67	10 8	51	1 12	6	1 14	5	0 12	2	0 0	0	1 0	2	0 0	0	0 10	1	0 0	0	0 0	0	1.00	....
1914	9 12	35	6 0	24	3 0	9	0 12	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1915	18 6	55	5 15	23	3 9	11	4 8	12	1 4	3	1 7	3	0 8	1	0 9	1	0 10	1	0 0	0	0 0	0	2.33	....
Average	16. 5	51	5. 7	25	2. 2	7	2. 8	8	1. 2	3	1. 0	2	2. 0	4	0. 3	0. 5	1. 4	2	0	0	0	0	1.67	....
Cull fruits—																								
1912	6 4	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	....
1913	5 14	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1914	1 10	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00	....
1915	2 0	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00	....
Average	3. 9	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.47	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
84, tree No. 23–75–23, Valencia strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	27 4	55	0 3	0	1 3	3	2 4	6	5 4	12	5 7	11	5 3	10	1 3	2	6 9	11	0 0	0	0 0	0	0.67	....
1913	23 9	113	21 9	105	1 11	7	0 5	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1914	13 14	45	6 2	24	3 10	11	1 8	4	2 2	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
1915	44 11	136	6 3	29	9 4	30	10 2	29	11 6	30	7 12	18	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.67	....
Average	27.3	87	8.5	40	3.9	13	3.5	10	4.7	12	3.5	8	1.3	3	0.3	0.5	1.6	3	0	0	0	0	3.92	....
Cull fruits—																								
1912	12 10	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1913	2 9	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.33	....
1914	1 0	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....
1915	2 11	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
Average	4.7	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
Total crop—																								
1912	84 12	167	0 7	1	2 9	7	3 6	9	12 8	29	14 11	31	14 7	29	3 5	6	16 11	28	4 2	6	0 0	0	.78	5
1913	125 0	507	69 4	298	38 13	125	9 0	26	4 8	12	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	12
1914	67 15	197	23 4	80	17 6	48	11 8	29	12 12	29	0 15	2	1 2	2	0 0	0	0 0	0	0 0	0	0 0	0	3.56	18
1915	123 11	362	11 10	49	20 1	64	26 4	76	40 8	107	19 5	45	3 4	7	0 0	0	0 0	0	0 0	0	0 0	0	5.00	44
Average	**100.3**	**308**	**26.1**	**107**	**19.7**	**61**	**12.5**	**35**	**17.6**	**44**	**9.0**	**20**	**4.7**	**10**	**0.8**	**2**	**4.2**	**7**	**1.0**	**2**	**0**	**0**	**3.42**	**20**
85, tree No. 23–88–7, Valencia strain:																								
Orchard grade—																								
1912	22 5	38	0 4	1	0 0	0	0 0	0	1 4	3	0 15	2	7 7	14	1 11	3	3 2	5	7 10	10	0 0	0	1.33	....
1913	84 3	264	23 1	91	23 12	76	16 1	45	16 8	42	2 3	5	2 0	4	0 10	1	0 0	0	0 0	0	0 0	0	2.67	....
1914	83 11	209	11 11	38	18 12	50	27 9	66	22 8	49	2 1	4	1 2	2	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1915	96 6	277	5 2	19	14 13	49	28 5	84	39 15	106	6 13	16	0 14	2	0 8	1	0 0	0	0 0	0	0 0	0	4.00	....
Average	71.6	197	10.0	37	14.3	44	18.0	49	20.1	50	3.0	7	2.9	6	0.7	1	0.8	1	1.9	3	0	0	2.67	....

| | | |

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
86, tree No. 23-90-5, Unproductive strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	125 5	252	1 14	7	1 11	5	3 11	10	16 9	39	17 12	38	28 7	54	4 0	7	23 14	39	8 15	13	0 0	0	0.44	10
1913	68 2	280	31 10	140	18 6	57	7 5	20	6 2	15	0 13	2	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	3.89	4
1914	130 5	435	76 12	286	31 6	90	13 6	34	6 6	14	0 8	1	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	3.78	54
1915	65 5	188	4 8	18	18 1	58	13 6	39	14 13	38	6 3	14	4 12	10	1 2	2	0 10	1	0 0	0	0 0	0	5.22	17
Average	**97.3**	**289**	**28.7**	**113**	**17.4**	**53**	**9.4**	**26**	**11.0**	**27**	**6.3**	**14**	**8.7**	**17**	**1.3**	**2**	**6.1**	**10**	**2.2**	**3**	**0**	**0**	**3.33**	**21**
87, tree No. 23-77-21, Valencia strain:																								
Orchard grade—																								
1912	22 2	40	0 4	1	0 0	0	0 6	1	1 10	4	2 6	5	6 6	12	0 9	1	3 2	5	7 7	11	0 0	0	1.33	....
1913	89 10	304	29 6	120	33 6	110	14 7	42	10 11	28	1 12	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	86 2	227	18 0	57	22 9	62	27 14	69	13 4	30	3 7	7	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1915	97 7	270	7 15	29	12 12	41	22 2	65	41 10	106	10 9	24	1 14	4	0 9	1	0 0	0	0 0	0	0 0	0	6.67	....
Average	73.8	210	13.9	52	17.2	53	16.2	44	16.8	42	4.5	10	2.3	5	0.3	0.5	0.8	1	1.9	3	0	0	3.25	....
Standard grade—																								
1912	11 11	23	0 4	1	0 5	1	0 6	1	3 3	7	0 9	1	3 12	7	0 10	1	2 10	4	0 0	0	0 0	0	.67	....
1913	23 12	107	18 10	90	3 13	13	0 15	3	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	14 11	48	6 8	26	3 10	11	1 7	4	1 3	3	1 6	3	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	32 5	103	5 6	18	16 9	56	7 0	21	2 12	7	0 10	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.67	....
Average	20.6	70	7.7	34	6.1	20	2.4	7	1.9	5	0.6	1	1.1	2	0.2	0.3	0.7	1	0	0	0	0	3.00	....
Cull fruits—																								
1912	3 8	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1913	3 11	52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.00	....
1914	1 1	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	....
1915	1 6	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
Average	2.4	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.83	....

Total crop—																														
1912	37	5	69	0	8	2	0	5	1	0	12	2	4	13	11	2	15	6	10	2	19	1	3	2	5	12	9	7	7	11	0	0	0	1.33	0
1913	117	1	463	48	1	210	37	3	123	15	6	45	11	1	29	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	9
1914	101	14	288	24	8	83	26	3	73	29	5	73	14	7	33	4	13	10	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	2.56	4
1915	131	2	380	13	5	47	29	5	97	29	2	86	44	6	113	11	3	25	1	14	4	0	9	1	0	0	0	0	0	0	0	0	0	4.78	7
Average	**96.8**		**300**	**21.6**		**86**	**23.3**		**74**	**18.6**		**52**	**18.7**		**47**	**5.2**		**11**	**3.4**		**7**	**0.4**		**1**	**1.4**		**2**	**1.9**		**3**	**0**		**0**	**3.00**	**3**
88, tree No. 23-86-3, Valencia strain:																																			
Orchard grade—																																			
1912	44	4	84	0	0	0	0	5	1	1	2	3	3	13	9	9	15	21	10	5	20	4	1	7	11	2	18	3	9	5	0	0	0	1.33	....
1913	73	14	278	45	1	190	19	6	63	4	15	14	2	12	7	0	8	1	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	1.33	....
1914	64	13	157	6	13	21	19	9	51	17	3	41	15	14	34	3	2	6	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	88	0	253	3	13	15	9	8	33	27	10	85	34	10	92	7	13	18	4	1	9	0	9	1	0	0	0	0	0	0	0	0	0	8.00	....
Average	67.7		193	13.9		57	12.3		37	12.7		36	14.3		36	5.3		12	4.5		9	1.2		2	2.8		5	0.9		1	0		0	3.92	....
Standard grade—																																			
1912	25	4	49	0	0	0	0	0	0	1	3	3	4	7	10	5	7	11	8	13	16	1	10	3	3	12	6	0	0	0	0	0	0	.67	....
1913	20	14	101	18	0	92	2	1	7	0	6	1	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.67	....
1914	7	13	21	1	2	4	2	2	6	0	6	1	3	5	8	0	7	1	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1915	39	6	124	11	4	43	14	5	44	10	1	28	1	15	5	0	13	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
Average	23.3		74	7.6		35	4.6		14	3.0		8	2.5		6	1.7		4	2.6		5	0.4		1	0.9		2	0		0	0		0	2.59	....
Cull fruits—																																			
1912	10	0	22																															0	....
1913	3	13	62																															4.33	....
1914	0	8	2																															4.50	....
1915	1	12	8																															3.67	....
Average	4.0		24																															3.13	....
Total crop—																																			
1912	79	8	155	0	0	0	0	5	1	2	5	6	8	4	19	15	6	32	19	2	36	5	11	10	14	14	24	3	9	5	0	0	0	.56	11
1913	97	9	441	63	1	282	21	7	70	5	5	15	3	3	8	0	8	1	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	2.11	9
1914	73	2	180	7	15	25	21	11	57	17	9	42	19	3	42	3	9	7	2	11	5	0	0	0	0	0	0	0	0	0	0	0	0	4.63	15
1915	129	2	385	15	1	58	23	13	77	37	11	113	36	9	97	8	10	20	5	1	11	0	9	1	0	0	0	0	0	0	0	0	0	5.33	13
Average	**94.8**		**290**	**21.5**		**91**	**16.8**		**51**	**15.7**		**44**	**16.8**		**42**	**7.0**		**15**	**7.0**		**14**	**1.6**		**3**	**3.7**		**6**	**0.9**		**1**	**0**		**0**	**3.16**	**12**
89, tree No. 23-91-6, Coarse strain:																																			
Orchard grade—																																			
1912	6	3	11	0	0	0	0	0	0		0	0	0	6	1	0	0	0	2	4	4	0	9	1	2	6	4	0	10	1	0	0	0	.50	....
1913	104	12	398	44	3	203	31	12	113	8	15	28	14	1	40	2	17	7	3	2	7	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	12	5	40	4	10	18	5	0	15	2	4	6	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	16	14	33	0	0	0	0	5	1	0	6	1	1	10	4	2	5	5	5	0	10	4	12	8	1	13	3	0	11	1	0	0	0	5.67	....
Average	35.0		121	12.2		55	9.3		32	3.1		9	4.1		12	1.3		3	2.6		5	1.3		2	1.1		2	0.3		0.5	0		0	3.38	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
89, tree No. 23-91-6, Coarse strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	8 8	17	0 0	0	0 0	0	0 6	1	1 3	3	0 7	1	3 15	8	0 0	0	2 9	4	0 0	0	0 0	0	2.00	....
1913	43 7	201	30 11	164	6 3	21	1 2	3	2 8	7	0 7	1	0 14	2	0 8	1	0 8	1	0 10	1	0 0	0	1.33	....
1914	108 5	328	27 2	105	26 14	86	12 6	36	19 8	51	10 6	24	10 9	23	0 0	0	0 6	1	1 2	2	0 0	0	1.00	....
1915	42 8	94	0 10	3	1 14	6	3 4	9	6 1	16	7 9	17	9 1	18	7 6	14	4 8	8	1 7	2	0 12	1	4.67	....
Average	50.7	160	14.6	68	8.7	28	4.3	12	7.3	19	4.7	11	6.1	13	2.0	4	2.0	4	0.8	1	0.2	0.3	2.25	....
Cull fruits—																								
1912	27 1	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.33	....
1913	3 11	69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00	....
1914	1 9	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....
1915	1 4	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....
Average	8.4	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.29	....
Total crop—																								
1912	41 12	74	0 0	0	0 0	0	0 6	1	1 9	4	0 7	1	6 3	12	0 9	1	4 15	8	0 10	1	0 0	0	1.37	0
1913	151 14	668	74 14	367	37 15	134	10 1	31	16 9	47	3 2	8	4 0	9	0 8	1	0 8	1	0 10	1	0 0	0	2.22	0
1914	122 3	379	31 12	123	31 14	101	14 10	42	19 15	52	10 6	24	10 9	23	0 0	0	0 6	1	1 2	2	0 0	0	2.78	38
1915	60 10	131	0 10	3	2 3	7	3 10	10	7 11	20	9 14	22	14 1	28	12 2	22	6 5	11	2 2	3	0 12	1	4.22	35
Average	**94.1**	**313**	**26.8**	**123**	**18.0**	**61**	**7.2**	**21**	**11.4**	**31**	**6.0**	**14**	**8.3**	**18**	**3.3**	**6**	**3.0**	**5**	**1.1**	**2**	**0.2**	**0.3**	**2.61**	**18**
90, tree No. 23-91-9, Coarse strain:																								
Orchard grade—																								
1912	38 9	82	0 0	0	1 1	3	5 9	15	6 13	16	7 8	16	11 10	22	2 15	5	3 1	5	0 0	0	0 0	0	0	....
1913	43 5	123	6 11	26	10 7	32	10 0	27	12 12	31	2 14	6	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	1.67	....
1914	79 6	247	39 10	137	29 6	84	9 0	23	1 6	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1915	26 6	56	0 0	0	0 0	0	1 15	5	6 2	15	6 1	13	6 2	12	6 2	11	0 0	0	0 0	0	0 0	0	3.00	....
Average	46.9	127	11.6	41	10.2	30	6.6	18	6.8	16	4.1	9	4.6	9	2.3	4	0.8	1	0	0	0	0	2.25	....

Standard grade—																																			
1912	37	12	85	1	12	6	1	1	3	5	11	15	10	14	26	5	12	12	8	6	16	1	12	3	2	8	4	0	0	0	0	0	0	0	
1913	19	12	78	13	8	60	3	14	12	1	14	5	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1914	54	12	200	36	4	147	13	4	40	3	2	8	2	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	38	7	100	2	9	11	5	8	18	6	4	17	10	11	26	8	0	18	2	9	5	1	9	3	0	0	0	1	5	2	0	0	4.67	....
Average	37.7		116	13.5		56	5.9		18	4.2		11	5.9		14	3.6		8	2.7		5	0.8		2	0.6		1	0.3		.05	0	0	2.83	....
Cull fruits—																																		
1912	14	1	30																													0	....
1913	2	14	37																													2.00	....
1914	1	10	10																													1.67	....
1915	2	3	10																													4.33	....
Average	5.2		22																													2.00	....
Total crop—																																		
1912	90	6	197	1	12	6	2	2	6	11	4	30	17	11	42	13	4	28	20	0	38	4	11	8	5	9	9	0	0	0	0	0	.03	3
1913	65	15	238	20	3	86	14	5	44	11	14	32	12	12	31	3	6	7	0	9	1	0	0	0	0	0	0	0	0	0	0	0	2.56	4
1914	135	12	457	75	14	284	42	10	124	12	2	31	3	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.89	33
1915	67	0	166	2	9	11	5	8	18	8	3	22	16	13	41	14	1	31	8	11	17	7	11	14	0	0	0	1	5	2	0	0	4.00	11
Average	**89.8**		**265**	**25.1**		**97**	**16.1**		**48**	**10.9**		**29**	**12.7**		**31**	**7.7**		**17**	**7.3**		**14**	**3.1**		**6**	**1.4**		**2**	**0.3**		**0.5**	**0**	**0**	**2.36**	**13**
91, tree No. 23-89-4, Unproductive strain:																																		
Orchard grade—																																		
1912	68	13	165	2	6	9	7	1	21	9	5	25	24	8	58	16	0	34	8	6	16	0	9	1	0	10	1	0	0	0	0	0	2.33	....
1913	60	1	179	18	4	70	15	7	46	9	1	24	11	14	28	4	6	9	1	1	2	0	0	0	0	0	0	0	0	0	0	0	2.00	....
1914	80	15	251	48	12	167	20	15	57	7	10	19	3	10	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
1915	18	5	40	0	0	0	0	10	2	1	12	5	4	3	10	3	3	7	2	14	6	4	7	8	0	10	1	0	10	1	0	0	5.00	....
Average	57.0		159	17.3		62	11.0		32	6.9		18	11.1		26	5.9		13	3.1		6	1.3		2	0.3		0.5	0.2		0.3	0	0	3.33	....
Standard grade—																																		
1912	57	8	146	9	5	33	7	7	22	12	14	34	9	0	21	10	0	20	7	11	14	0	0	0	1	3	2	0	0	0	0	0	2.00	....
1913	23	11	104	17	3	85	3	8	12	1	2	3	1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
1914	23	5	91	18	13	78	3	0	9	0	10	2	0	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
1915	6	2	15	0	4	1	0	10	2	1	2	3	1	11	4	0	14	2	1	0	2	0	9	1	0	0	0	0	0	0	0	0	4.67	....
Average	27.7		89	11.4		49	3.6		11	3.9		11	3.4		8	2.7		6	2.2		4	0.1		0.3	0.3		0.5	0		0	0	0	3.67	....
Cull fruits—																																		
1912	4	10	15																													1.67	....
1913	5	0	52																													4.00	....
1914	1	12	11																													1.67	....
1915	0	14	3																													4.33	....
Average	3.1		20																													2.92	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
91, tree No. 23–89–4, Unproductive strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	130 15	326	11 11	42	14 8	43	22 3	59	33 8	79	26 0	54	16 1	30	0 9	1	1 13	3	0 0	0	0 0	0	2.00	4
1913	88 12	335	35 7	155	18 15	58	10 3	27	13 12	32	4 6	9	1 1	2	0 0	0	0 0	0	0 0	0	0 0	0	3.11	4
1914	106 0	353	67 9	245	23 15	66	8 4	21	4 8	10	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.14	54
1915	25 5	58	0 4	1	1 4	4	2 14	8	5 14	14	4 1	9	3 14	8	5 0	9	0 10	1	0 10	1	0 0	0	4.67	5
Average	**87.8**	**268**	**28.7**	**111**	**14.7**	**43**	**10.9**	**29**	**14.4**	**34**	**8.6**	**18**	**5.3**	**10**	**1.4**	**3**	**0.6**	**1**	**0.2**	**0.3**	**0**	**0**	**3.31**	**17**
92, tree No. 23–77–18, Valencia strain:																								
Orchard grade—																								
1912	33 14	83	0 4	1	2 12	9	5 3	15	8 12	22	5 9	13	8 8	18	1 2	2	0 8	1	1 4	2	0 0	0	2.00	....
1913	68 5	216	12 1	48	26 8	86	12 3	36	14 15	40	2 2	5	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1914	60 4	167	3 10	28	22 12	58	16 4	41	13 5	30	3 4	8	0 8	1	0 9	1	0 0	0	0 0	0	0 0	0	3.33	....
1915	65 10	160	0 0	0	4 8	14	3 14	11	29 10	75	15 12	36	8 4	17	3 10	7	0 0	0	0 0	0	0 0	0	2.67	....
Average	57.0	157	4.0	19	14.1	42	9.4	26	16.7	42	6.7	16	4.4	9	1.3	3	0.1	0.3	0.3	0.5	0	0	3.25	....
Standard grade—																								
1912	40 2	98	2 9	9	3 9	11	6 2	17	9 4	23	7 14	17	8 8	17	0 9	1	1 11	3	0 0	0	0 0	0	1.00	....
1913	25 3	101	14 6	65	7 9	26	2 8	8	0 12	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
1914	10 15	33	3 12	13	4 11	14	0 12	2	1 4	3	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1915	25 13	80	3 2	18	3 8	12	6 6	19	6 9	17	5 2	12	0 0	0	1 2	2	0 0	0	0 0	0	0 0	0	2.33	....
Average	25.5	78	6.0	26	4.8	16	3.9	11	4.5	11	3.4	8	2.1	4	0.4	1	0.4	1	0	0	0	0	2.42	....
Culls fruits—																								
1912	4 0	12																					0	....
1913	2 9	36																					2.00	....
1914	1 4	7																					.67	....
1915	0 11	3																					3.00	....
Average	2.1	15																					1.42	....

Total crop																														
1912	78	0	193	2	13	10	6	5	20	11	5	32	18	0	45	13	7	30	17	0	35	1	11	3	2	3	4	1	4	2	0	0	0	1.00	4
1913	96	1	353	26	7	113	34	1	112	14	11	44	15	11	42	2	2	5	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	3.22	6
1914	72	7	207	7	6	41	27	7	72	17	0	43	14	9	33	3	12	9	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	2.56	5
1915	92	2	243	3	2	18	8	0	26	10	4	30	36	3	92	20	14	48	8	4	17	4	12	9	0	0	0	0	0	0	0	0	0	2.67	10
Average	**84.**	**6**	**249**	**9.**	**9**	**46**	**19.**	**0**	**58**	**13.**	**3**	**37**	**21.**	**1**	**53**	**10.**	**1**	**23**	**6.**	**6**	**14**	**1.**	**8**	**3**	**0.**	**5**	**1**	**0.**	**3**	**0.**	**5**	**0**	**0**	**2.36**	**6**
93, tree No. 23-88-5, Rough strain:																																			
Orchard grade—																																			
1912	4	0	9	0	0	0	0	5	1	0	12	2	0	0	0	0	15	2	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1.00	....
1913	3	4	9	0	7	2	1	0	3	0	14	2	0	0	0	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1914	19	11	67	13	6	50	4	5	12	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1915	13	4	29	0	0	0	0	0	0	0	5	1	3	8	9	1	13	4	5	6	11	1	2	2	1	2	2	0	0	0	0	0	0	3.67	....
Average	10.	1	29	3.	5	13	1.	4	4	1.	0	3	0.	9	2	0.	9	2	1.	8	4	0.	3	0.	5	0.	3	0.	5	0	0	0	0	2.50	....
Standard grade—																																			
1912	98	12	240	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		1.00	....
1913	55	1	176	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		1.00	....
1914	92	0	341	67	2	268	18	14	59	3	4	9	1	3	3	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	41	5	104	0	13	4	4	7	14	8	14	25	9	11	24	13	14	30	1	14	4	1	12	3	0	0	0	0	0	0	0	0	0	2.33	....
Average	7.	18	215	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		1.75	....
Cull fruits—																																			
1912	0	0	0	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		[a]1.33	....
1913	1	8	11	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		.67	....
1914	1	3	7	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		2.33	....
1915	0	2	3	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		[b]	....
Average	0.	7	5	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		1.44	....
Total crop—																																			
1912	102	12	249	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		1.11	21
1913	59	13	196	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		1.38	31
1914	112	14	415	81	2	318	23	3	71	5	4	14	1	3	3	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	89
1915	54	11	136	0	13	4	4	7	14	9	3	26	13	3	33	15	11	34	7	4	15	2	14	5	1	2	2	0	0	0	0	0	0	3.00	44
Average	**82.**	**5**	**249**	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		....	....		**1.97**	**46**
94, tree No. 23-89-5, Unproductive strain:																																			
Orchard grade—																																			
1912	36	3	86	1	7	5	3	9	11	3	9	11	10	13	26	6	14	15	5	2	10	1	2	2	2	6	4	1	5	2	0	0	0	1.00	....
1913	52	9	136	7	2	28	10	12	32	7	11	21	8	9	20	6	11	14	7	8	14	1	2	2	3	2	5	0	0	0	0	0	0	5.00	....
1914	100	15	313	56	1	194	24	14	70	16	12	42	3	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1915	19	0	42	0	0	0	0	5	1	2	0	6	3	12	9	5	9	12	4	9	9	2	13	5	0	0	0	0	0	0	0	0	0	5.00	....
Average	52.	1	144	16.	2	57	9.	9	29	7.	5	20	6.	6	16	4.	8	10	4.	3	8	1.	3	2	1.	4	2	0.	3	0.	5	0	0	3.83	....

[a] Result of the examination of three Rough-strain fruits.

[b] No count was made to determine the seed content of the fruits in this group.

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																				Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
94, tree No. 23-89-5, Unproductive strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	35 9	78	1 11	7	2 1	6	3 10	9	6 0	14	8 4	17	11 0	20	0 9	1	2 6	4	0 0	0	0 0	0	2.00	....
1913	12 0	45	6 8	32	1 0	3	0 14	2	2 9	6	0 7	1	0 10	1	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1914	13 14	51	8 0	34	4 4	13	0 12	2	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	31 6	85	1 14	8	5 0	16	8 10	24	8 9	21	6 13	15	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	6.67	....
Average	23.2	65	4.5	20	3.1	9	3.5	9	4.5	11	3.9	8	3.0	6	0.1	0.3	0.6	1	0	0	0	0	3.92	....
Cull fruits—																								
1912	16 1	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.67	....
1913	4 6	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1914	1 4	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.33	....
1915	0 0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(*a*)	....
Average	5.4	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.92	....
Total crop—																								
1912	87 13	196	3 2	12	5 10	17	7 3	20	16 13	40	15 2	32	16 2	30	1 11	3	4 12	8	1 5	2	0 0	0	1.56	2
1913	68 15	226	13 10	60	11 12	35	8 9	23	11 2	26	7 2	15	8 2	15	1 2	2	3 2	5	0 0	0	0 0	0	3.11	6
1914	116 1	374	64 1	228	29 2	83	17 8	44	4 2	9	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	31
1915	50 6	127	1 14	8	5 5	17	10 10	30	12 5	27	12 6	10	5 1	10	2 13	5	0 0	0	0 0	0	0 0	0	5.83	12
Average	**80.8**	**231**	**20.7**	**77**	**13.0**	**38**	**11.0**	**29**	**11.1**	**26**	**8.7**	**14**	**7.3**	**14**	**1.4**	**3**	**2.0**	**3**	**0.3**	**0.5**	**0**	**0**	**3.15**	**13**
95, tree No. 23-89-6, Unproductive strain:																								
Orchard grade—																								
1912	31 6	62	0 8	1	0 6	1	0 12	2	4 14	12	5 4	11	10 14	21	1 0	2	3 2	5	4 10	7	0 0	0	1.33	....
1913	57 9	188	20 6	85	14 2	44	11 8	32	7 10	19	1 14	4	2 1	4	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1914	64 13	191	25 14	87	20 1	57	14 14	38	4 0	9	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.00	....
1915	22 13	61	0 8	2	2 15	9	6 2	18	10 8	26	1 12	4	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	7.33	....
Average	44.1	126	11.8	44	9.4	28	8.3	23	6.8	17	2.2	5	3.5	7	0.3	0.5	0.8	1	1.2	2	0	0	4.00	....

Standard grade—																																
1912	45	12	95	0	0	0	3	10	10	3	12	10	7	5	17	8	11	18	12	6	23	2	14	5	7	2	12	0	0	0	0	0	0	1.33	....
1913	20	1	89	15	2	74	3	6	11	1	2	3	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1914	24	8	80	9	3	37	8	5	25	1	12	5	4	0	10	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
1915	43	9	130	1	13	8	12	15	44	13	10	40	10	11	28	4	8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
Average	33.	5	99	6.	5	30	7.	1	23	5.	1	15	5.	5	14	3.	7	8	3.	1	6	0.	7	1	1.	8	3	0		0		0	0	2.84	....
Cull fruits—																																
1912	1	0	29																													0	....
1913	5	0	83																													4.33	....
1914	0	9	3																													2.33	....
1915	3	7	12																													5.33	....
Average	2.	5	32																													3.00	....
Total crop—																																
1912	78	2	186	0	8	1	4	0	11	4	8	12	12	3	29	13	15	29	23	4	44	3	14	7	10	4	17	4	10	7	0	0	0	.89	2
1913	82	10	360	35	8	159	17	8	55	12	10	35	7	10	19	2	5	5	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	3.44	5
1914	89	14	274	35	1	124	28	6	82	16	10	43	8	0	19	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	53
1915	69	13	203	2	5	10	15	14	53	19	12	58	21	3	54	6	10	14	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5.78	21
Average	**80.**	**1**	**256**	**18.**	**3**	**74**	**16.**	**5**	**50**	**13.**	**4**	**37**	**12.**	**3**	**30**	**6.**	**0**	**13**	**6.**	**6**	**13**	**1.**	**0**	**2**	**2.**	**5**	**4**	**1.**	**2**	**2**		**0**	**0**	**3.28**	**20**
96, tree No. 23-85-1, Small Yellow strain:																																
Orchard grade—																																
1912	32	0	92	5	5	20	11	10	35	7	9	20	4	2	10	2	14	6	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	....
1913	48	6	219	41	9	198	4	5	14	1	6	4	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.67	....
1914	18	4	46	6	5	19	3	13	10	3	14	9	3	1	6	0	9	1	0	0	0	0	10	1	0	0	0	0	0	0	0	0	0	1.00	....
1915	45	15	175	20	12	90	15	12	56	6	9	21	2	8	7	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
Average	36.	1	133	18.	5	82	8.	9	29	4.	8	14	2.	7	7	1.	0	2	0.	1	0.	3	0.	2	0.	3	0	0		0		0	0	1.50	....
Standard grade—																																
1912	12	9	39	5	1	19	3	6	10	2	0	5	1	11	4	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	....
1913	17	3	96	16	5	93	0	8	2	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	....
1914	29	15	104	21	4	82	6	13	18	0	14	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	....
1915	87	8	392	79	4	367	6	13	21	1	0	3	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
Average	36.	8	158	30.	1	140	4.	4	13	1.	1	3	0.	7	2	0.	2	0.	5	0	0	0		0	0		0	0		0		0	0	2.17	....
Cull fruits—																																
1912	12	12	44																													0	....
1913	5	7	83																													1.33	....
1914	0	8	4																													1.67	....
1915	5	15	35																													3.00	....
Average	6.	2	42																													1.50	....

[a] No count was made to determine the seed content of the fruits in this group.

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
96, tree No. 23-85-1, Small Yellow strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	57 5	175	10 6	39	15 0	45	9 9	25	5 13	14	3 5	7	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0	46
1913	71 0	398	57 14	291	4 13	16	1 12	5	1 2	3	0 0		0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.11	4
1914	48 11	154	27 9	101	10 10	28	4 12	11	4 1	8	0 9	1	0 0	0	0 10	1	0 0	0	0 0	0	0 0	0	1.67	59
1915	139 6	602	100 0	457	22 9	77	7 9	24	2 8	7	0 13	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.11	63
Average	**79.1**	**332**	**49.0**	**222**	**13.3**	**42**	**5.9**	**16**	**3.4**	**8**	**1.2**	**3**	**0.1**	**0.3**	**0.2**	**0.3**	**0**	**0**	**0**	**0**	**0**	**0**	**1.88**	**43**
97, tree No. 23-91-3, Unproductive strain:																								
Orchard grade—																								
1912	28 6	58	0 4	1	1 4	4	0 6	1	3 10	9	7 8	16	7 11	15	1 1	2	3 10	6	3 0	4	0 0	0	.33	....
1913	25 9	94	15 1	62	6 4	20	2 12	8	1 1	3	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	80 13	258	48 15	170	22 2	62	8 2	22	1 10	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1915	43 4	133	7 9	28	12 13	41	12 6	36	10 8	28	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
Average	44.5	136	18.0	65	10.6	32	5.9	17	4.2	11	2.0	4	1.9	4	0.3	0.5	0.9	2	0.8	1	0	0	2.25	....
Standard grade—																								
1912	35 13	77	0 12	3	2 0	6	2 12	7	7 13	18	6 12	14	12 4	23	1 0	2	2 8	4	0 0	0	0 0	0	.33	....
1913	19 4	93	17 1	86	1 8	5	0 11	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.67	....
1914	14 13	58	11 3	47	2 8	8	0 6	1	0 12	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1915	37 12	129	13 8	54	16 11	54	6 12	19	0 6	1	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.67	....
Average	26.9	89	10.6	48	5.7	18	2.6	7	2.2	5	1.8	4	3.1	6	0.3	0.5	0.6	1	0	0	0	0	2.42	....
Cull fruits—																								
1912	4 8	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.67	....
1913	4 12	78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.33	....
1914	1 6	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.67	....
1915	1 6	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.33	....
Average	3.0	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.25	....

Total crop—																																
1912	68	11	146	1	0	4	3	4	10	3	2	8	11	7	27	14	4	30	19	15	38	2	1	4	6	2	10	3	0	4	0	0	0	.44	5
1913	49	9	265	32	2	148	7	12	25	3	7	10	1	1	3	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	4
1914	97	0	324	60	2	217	24	10	70	8	8	23	2	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.56	31
1915	82	6	272	21	1	82	29	8	95	19	2	55	10	14	29	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.22	22
Average	**74.4**		**252**	**28.6**		**113**	**16.3**		**50**	**8.5**		**24**	**6.4**		**16**	**3.8**		**8**	**5.0**		**10**	**0.5**		**1**	**1.5**		**3**	**0.8**		**1**	**0**		**0**	**2.31**	**16**
98, tree No. 23-98-1, Yellow strain:																																			
Orchard grade—																																			
1912	11	10	33	1	14	7	4	0	12	2	3	6	2	15	7	0	0	0	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	.67	....
1913	64	8	264	55	9	239	5	7	16	2	4	6	0	13	2	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	....
1914	51	13	198	40	14	172	3	10	11	2	10	6	2	6	5	0	8	1		3	2	0	10	1	0	0	0	0	0	0	0	0	0	1.67	....
1915	17	15	52	3	7	13	5	4	16	4	2	11	2	14	7	1	4	3	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2.67	....
Average	36.5		137	25.4		108	4.6		14	2.8		7	2.3		5	0.5		1	0.7		1	0.2		0.3	0		0	0		0	0		0	1.50	....
Standard grade—																																			
1912	15	7	46	7	3	26	2	14	8	1	9	4	1	12	4	1	8	3	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	.33	....
1913	18	5	93	18	5	93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	....
1914	19	9	98	17	1	91	2	2	6	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1915	60	6	208	22	6	93	21	3	70	12	9	35	3	3	8	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	.67	....
Average	28.4		111	16.2		76	6.5		21	3.5		10	1.3		3	0.5		1	0.3		0.5	0		0	0		0	0		0	0		0	1.00	....
Cull fruits—																																			
1912	16	8	47	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	0	....
1913	5	4	64	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	0	....
1914	3	12	46	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.67	....
1915	3	5	20	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.00	....
Average	7.2		44	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.42	....
Total crop—																																			
1912	43	9	126	9	1	33	6	14	20	3	12	10	4	11	11	1	8	3	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	.33	8
1913	88	1	421	73	14	332	5	7	16	2	4	6	0	13	2	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.43	216
1914	75	2	342	57	15	263	5	12	17	2	10	6	2	12	6	0	8	1	1	3	2	0	10	1	0	0	0	0	0	0	0	0	0	1.78	29
1915	81	10	280	25	13	106	26	7	86	26	11	46	6	1	15	1	12	4	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	1.44	105
Average	**72.1**		**292**	**41.7**		**184**	**11.1**		**35**	**8.8**		**17**	**3.6**		**9**	**1.0**		**2**	**1.0**		**2**	**0.2**		**0.3**	**0**		**0**	**0**		**0**	**0**		**0**	**1.00**	**90**
99, tree No. 23-89-11, Unproductive strain:																																			
Orchard grade—																																			
1912	29	14	90	9	13	37	7	12	23	4	1	11	5	6	13	2	6	5	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	.33	....
1913	36	6	164	31	6	149	3	8	11	1	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.33	....
1914	29	7	101	25	1	89	3	10	10	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	....
1915	44	7	135	14	11	52	9	12	30	10	10	30	8	7	21	0	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
Average	35.0		123	20.2		82	6.2		19	4.2		11	3.5		9	0.8		2	0.1		0.3	0		0	0		0	0		0	0		0	1.42	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
99, tree No. 23-89-11, Unproductive strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	10 3	32	5 13	20	2 6	7	1 8	4	0 0	0	0 0	0	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0.33	....
1913	21 10	117	20 4	112	1 0	4	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.00	....
1914	11 8	54	9 14	49	1 4	4	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.00	....
1915	38 12	154	24 4	111	9 3	30	1 8	4	2 0	5	1 13	4	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	.67	....
Average	20.5	89	15.1	73	3.5	11	0.9	3	0.5	1	0.5	1	0.1	0.3	0	0	0	0	0	0	0	0	1.25	....
Cull fruits—																								
1912	5 5	21																					0	....
1913	6 12	168																					1.00	....
1914	4 12	37																					.67	....
1915	4 13	25																					2.67	....
Average	5.4	63																					1.08	....
Total crop—																								
1912	45 6	143	15 10	57	10 2	30	5 9	15	5 6	13	2 6	5	1 0	2	0 0	0	0 0	0	0 0	0	0 0	0	.22	0
1913	64 12	449	51 10	261	4 8	15	1 14	5	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.78	124
1914	45 11	192	34 15	138	4 14	14	1 2	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	.89	5
1915	88 0	314	38 15	163	18 15	60	12 2	34	10 7	26	2 12	6	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	2.11	16
Average	**61.0**	**275**	**35.3**	**155**	**9.6**	**30**	**5.2**	**14**	**4.0**	**10**	**1.2**	**3**	**0.3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.25**	**36**
100, tree No. 23-89-3, Unproductive strain:																								
Orchard grade—																								
1912	29 8	67	0 8	2	1 5	4	2 15	8	9 7	23	6 9	14	6 5	12	0 0	0	1 12	3	0 11	1	0 0	0	1.67	....
1913	39 4	161	32 10	141	5 6	17	0 12	2	0 9	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	6.00	....
1914	55 12	167	26 4	90	18 0	49	10 4	25	1 4	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.33	....
1915	15 9	40	0 8	2	2 5	7	4 10	13	4 8	11	0 14	2	1 0	2	1 12	3	0 0	0	0 0	0	0 0	0	5.33	....
Average	35.0	109	15.0	59	6.8	19	4.6	12	3.9	10	1.9	4	1.8	4	0.4	1	0.4	1	0.4	0.3	0	0	3.58	....

Standard grade—																																			
1912	32	14	78	3	9	13	2	0	6	5	5	14	8	9	20	3	15	8	5	2	10	0	9	1	3	12	6	0	0	0	0	0	0	1.33	....
1913	15	5	65	11	10	61	0	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.50	....
1914	8	2	24	3	2	10	3	2	9	1	14	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.33	....
1915	23	6	69	0	8	2	7	8	26	8	9	24	5	3	13	1	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.67	....
Average	19.9		59	4.7		22	3.3		11	3.9		11	3.4		8	1.4		3	1.3		3	0.1		0.3	0.9		2	0		0	0		0	3.96	....
Cull fruits—																																			
1912	7	9	26	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	1.33	.....
1913	4	14	63	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	3.33	....
1914	1	7	10	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.33	....
1915	0	10	6	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.00	....
Average	3.6		26	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.25	....
Total crop—																																			
1912	69	15	171	4	1	15	3	5	10	8	4	22	18	1	43	10	8	22	11	7	22	0	9	1	5	8	9	0	11	1	0	0	0	1.44	4
1913	56	7	287	44	4	202	6	1	19	0	12	2	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.37	6
1914	65	5	201	29	6	100	21	2	53	12	2	30	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67	16
1915	39	9	115	1	0	4	9	13	33	13	3	37	9	11	24	2	8	6	1	0	2	1	12	3	0	0	0	0	0	0	0	0	0	4.67	15
Average	**57.8**		**194**	**19.7**		**80**	**10.1**		**30**	**8.6**		**23**	**7.4**		**18**	**3.3**		**7**	**3.1**		**6**	**0.6**		**1**	**1.4**		**2**	**0.4**		**0.3**	**0**		**0**	**3.26**	**10**
101, tree No. 23-93-4, Unproductive strain:																																			
Orchard grade—																																			
1912	10	5	21	0	0	0	0	0	0	0	6	1	1	10	4	3	3	7	3	4	6	0	9	1	0	10	1	0	11	1	0	0	0	1.33	....
1913	42	13	145	17	10	67	15	9	50	5	15	18	3	5	9	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00	....
1914	29	15	86	9	4	34	7	14	22	6	13	17	4	8	10	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.00	....
1915	49	13	136	1	6	5	10	2	32	12	1	34	17	14	46	6	6	15	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4.00	....
Average	33.2		97	7.1		27	8.4		26	6.3		18	6.8		17	2.9		7	1.6		3	0.1		0.3	0.2		0.3	0.2		0.3		0	0	2.58	....
Standard grade—																																			
1912	27	5	62	0	15	4	2	11	8	3	7	9	4	15	12	6	5	13	7	3	13	0	8	1	1	5	2	0	0	0	0	0	0	2.67	....
1913	12	12	57	11	3	52	1	4	4	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1914	17	12	54	5	10	23	5	4	16	1	4	3	1	12	4	2	6	5	1	8	3	0	0	0	0	0	0	0	0	0	0	0	0	3.67	....
1915	31	4	91	1	9	6	12	4	39	9	6	26	6	5	16	1	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.67	....
Average	22.3		66	4.8		21	5.4		17	3.6		10	3.3		8	2.6		6	2.2		4	0.1		0.3	0.3		0.5	0		0	0		0	4.00	....
Cull fruits—																																			
1912	2	12	7	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.67	....
1913	2	8	43	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.00	....
1914	1	3	7	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	5.00	....
1915	1	15	4	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	4.00	....
Average	2.1		15	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	.....		.....	2.92	....

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive*—Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
101, tree No. 23-93-4, Unproductive strain—Continued.																								
Total crop—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	40 6	90	0 15	4	2 11	8	3 13	10	6 9	16	9 8	20	10 7	19	1 1	2	1 15	3	0 11	1	0 0	0	1.56	1
1913	58 1	245	28 13	119	16 13	54	6 4	19	3 5	9	0 6	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	3.33	0
1914	48 14	147	14 14	57	13 2	38	8 1	20	6 4	14	3 14	8	1 8	3	0 0	0	0 0	0	0 0	0	0 0	0	3.56	30
1915	83 0	231	2 15	11	22 6	71	21 7	60	24 3	62	8 2	19	2 0	4	0 0	0	0 0	0	0 0	0	0 0	0	4.22	18
Average	**57.6**	**178**	**12.0**	**48**	**13.8**	**43**	**9.9**	**27**	**10.1**	**25**	**5.5**	**12**	**3.5**	**7**	**0.3**	**0.5**	**0.5**	**1**	**0.2**	**0.3**	**0**	**0**	**3.17**	**12**
102, tree No. 23-75-20, Unproductive strain:																								
Orchard grade—																								
1912	19 12	46	0 4	1	0 6	1	1 8	4	6 11	16	6 9	15	4 6	9	0 0	0	0 0	0	0 0	0	0 0	0	1.33	....
1913	39 1	131	14 14	57	17 12	56	5 5	15	1 2	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
1914	37 12	96	6 12	22	8 10	23	9 14	24	10 8	23	1 8	3	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	3.33	....
1915	33 0	91	3 7	12	5 7	16	7 14	22	13 2	34	3 2	7	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.33	....
Average	32.4	91	6.3	23	8.1	24	6.1	16	7.9	19	2.8	6	1.2	3	0	0	0	0	0	0	0	0	3.58	....
Standard grade—																								
1912	15 1	39	2 1	7	3 13	11	2 3	6	1 10	4	1 14	4	3 8	7	0 0	0	0 0	0	0 0	0	0 0	0	2.00	....
1913	20 9	90	17 7	80	2 7	8	0 11	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	5.00	....
1914	9 2	27	3 1	11	2 0	6	0 6	1	2 13	7	0 14	2	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.67	....
1915	13 12	44	2 1	9	4 15	7	3 2	9	2 6	6	1 4	3	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	4.33	....
Average	14.6	50	6.2	27	3.3	8	1.6	5	1.7	4	1.0	2	0.9	2	0	0	0	0	0	0	0	0	3.25	....
Cull fruits—																								
1912	5 4	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.00	....
1913	3 4	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.00	....
1914	1 4	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	....
1915	11 8	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.33	....
Average	5.3	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.83	....

Total crop—																														
1912	40	1	100	2	5	8	4	3	12	3	11	10	8	5	20	8	7	19	7	14	16	0	0	0	0	0	0	0	0	0	2.00	0
1913	62	14	261	32	5	137	20	3	64	6	0	17	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.50	12
1914	48	2	184	9	13	33	10	10	29	10	4	25	13	5	30	2	6	5	0	8	1	0	0	0	0	0	0	0	0	0	2.00	13
1915	58	4	145	5	8	21	10	6	33	11	0	31	15	8	40	4	6	10	0	0	0	0	0	0	0	0	0	0	0	0	5.33	27
Average	52.3		160	12.5		50	11.3		35	7.7		21	9.6		23	3.8		9	2.1		4	0		0	0		0	0		0	3.52	13
103, tree No. 27–84–12, Smooth strain:																														
Orchard grade—																														
1912	40	10	96	2	15	10	5	11	17	6	0	16	8	4	20	5	4	11	7	9	14	1	13	3	3	2	5	0	0	0	0	....
1913	9	6	30	4	2	16	1	15	6	1	6	4	0	14	2	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	2.00	....
1914	31	2	98	19	5	65	8	11	25	2	12	7	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.00	....
1915	27	8	74	2	3	8	6	6	20	6	8	18	7	7	18	1	14	4	2	0	4	1	2	2	0	0	0	0	0	0	6.33	....
Average	27.2		75	7.1		25	5.7		17	4.2		11	4.2		11	1.4		4	2.5		5	0.7		1	0.8		1	0		0	3.33	....
Standard grade—																														
1912	2	4	6	0	9	2	0	12	2	0	0	0	0	6	1	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	.67	....
1913	5	0	27	4	8	25	0	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.50	....
1914	18	4	63	8	12	35	5	10	18	1	0	3	2	14	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.67	....
1915	4	4	14	1	2	5	1	9	5	1	2	3	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.67	....
Average	7.4		28	3.7		17	2.1		7	0.5		2	0.9		2	0		0	0.1		0.3	0		0	0		0	0		0	3.88	....
Cull fruits—																														
1912	9	9	34																											1.67	....
1913	1	8	15																											4.33	....
1914	0	15	3																											1.67	....
1915	0	10	3																											1.67	....
Average	3.2		14																											2.34	....
Total crop—																														
1912	52	7	136	3	8	12	6	7	19	6	0	16	8	10	21	5	4	11	8	2	15	1	13	3	3	2	5	0	0	0	.78	34
1913	15	14	72	8	10	41	2	7	8	1	6	4	0	14	2	0	8	1	0	9	1	0	0	0	0	0	0	0	0	0	3.00	2
1914	50	5	164	28	1	100	14	5	43	3	12	10	3	4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.44	10
1915	32	6	91	3	5	13	7	15	25	7	10	21	7	14	19	1	14	4	2	0	2	1	2	2	0	0	0	0	0	0	4.56	8
Average	37.8		116	10.9		42	7.8		24	4.7		1.3	5.2		13	1.9		4	2.7		5	0.7		1	0.8		1	0		0	3.19	14
104, tree No. 37–57–25, Barren strain:																														
Orchard grade—																														
1912	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	....
1913	0	8	1	0	0	0	0	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	....
1914	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(a)	....
1915	5	9	12	0	3	1	0	0	0	0	0	0	1	9	4	0	0	0	2	0	4	0	9	1	1	4	2	0	0	0	1.33	....
Average	1.6		4	0.1		0.3	0	0	0	0	0	0	0.5		1	0		0	0.6		1	0.1		0.3	0.4		0.5	0		0	.33	....

a No count was made to determine the seed content of the fruits in this group.

TABLE I.—*Detailed statement of the annual performance of Valencia orange trees for which records were obtained for four years, 1912 to 1915, inclusive.* Con.

Rank, tree number, strain, grade, and year.	Sizes.																						Average number of seeds per fruit.	Number of variable fruits.
	Total.		288 and smaller.		250		216		200		176		150		126		112		96		80 and larger.			
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.		
104, tree No. 37-57-25, Barren strain—Continued.																								
Standard grade—	*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*			
1912	4 13	9	0 0	0	0 0	0	0 6	1	0 0	0	0 8	1	2 2	4	0 9	1	1 4	2	0 0	0	0 0	0	1.00	....
1913	4 4	14	2 0	9	1 2	3	0 0	0	0 7	1	0 0	0	0 6	0	0 11	1	0 0	0	0 0	0	0 0	0	2.00	....
1914	1 9	4	0 0	0	0 0	0	0 12	2	0 6	1	0 7	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	1.00	....
1915	6 2	12	0 0	0	0 14	3	0 0	0	0 0	0	0 15	2	0 8	1	0 9	1	1 12	3	0 11	1	0 13	1	4.00	....
Average	4.2	10	0.5	2	0.5	2	0.3	1	0.2	0.5	0.5	1	0.7	1	0.5	1	0.8	1	0.2	0.3	0.2	0.3	2.00	....
Cull fruits—																								
1912	7 7	25																					.67	....
1913	0 8	2																					0	....
1914	0 4	1																					0	....
1915	1 9	7																					0	....
Average	2.4	9																					.17	....
Total crop—																								
1912	12 12	35	0 0	0	0 0	0	0 6	1	0 0	0	0 8	1	2 10	5	0 9	1	1 4	2	0 0	0	0 0	0	.67	25
1913	5 4	17	2 0	9	1 2	3	0 0	0	0 15	2	0 0	0	0 0	0	0 11	1	0 0	0	0 0	0	0 0	0	1.00	0
1914	1 13	5	0 0	0	0 0	0	0 12	2	0 6	1	0 7	1	0 0	0	0 0	0	6 0	0	0 0	0	0 0	0	.75	0
1915	13 4	31	0 3	1	0 14	3	0 0	0	1 9	4	0 15	2	2 8	5	1 2	2	3 0	5	0 11	1	0 13	1	1.78	9
Average	**8.3**	**22**	**0.6**	**3**	**0.5**	**2**	**0.3**	**1**	**0.7**	**2**	**0.5**	**1**	**1.3**	**3**	**0.6**	**1**	**1.1**	**2**	**0.2**	**0.3**	**0.2**	**0.3**	**1.12**	**9**
105, tree No. 37-58-26, Barren strain:																								
Orchard grade—																								
1912	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	(*a*)	....
1913	0 8	1	0 0	0	0 0	0	0 0	0	0 8	1	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0	....
1914	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	(*a*)	....
1915	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	0 0	0	(*a*)	....
Average	0.1	0.3	0	0	0	0	0	0	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	....

| | | |

In each succeeding year of these investigations, the workers became familiar with an increasing number of variable forms of fruits and recorded their occurrence as they were observed. This accounts for the general increase from year to year in the number of such fruits recorded. Because of this increase in the number of variable forms observed, the figures given here as the average annual production of such fruits are too low, especially for those trees which have borne a large number of such variable fruits. When securing performance records, late-bloom fruit and split fruit have been recorded, but such fruits have not been included with the variable fruits.

In expressing the average of weights in Table I, it was found impracticable to retain more than one decimal place. The more exact expression of ounces as a fractional part of a pound extends to four decimal places, but only one place has been retained. In expressing the averages for the number of fruits occurring in different groups, no decimal has been retained except when the average number is less than unity. Hence, it will be found that the totals of averages sometimes will vary slightly from the average of the totals of the corresponding number.

In recording the tree-performance data the fruits of the Cull grade are not assorted into sizes, and on this account the total figures for the weights and numbers of fruits of the various sizes represent only the commercial crops of the trees.

In determining the average number of seeds per fruit on the different trees counts are made when possible from a small, a medium, and a large fruit in each of the three grades. In this way a record is usually secured of the actual number of seeds in 9 fruits from each tree, and it is thought that this system gives a fairly accurate indication of the relative seediness of the fruits of the different trees. To determine the annual average number of seeds per fruit, the total number of seeds found is divided by the total number of fruits examined during the entire period. In the case of trees from which less than 9 fruits have been examined during any season the average obtained in this way gives equal weight to each fruit and is fairer and more accurate than to average the yearly averages.

In counting the variable fruits occurring on individual trees, the strain of each tree is considered the standard for that tree, and all deviations from it are considered as variable fruits. For example, on a tree of the Valencia strain all fruits other than those of the Valencia strain are considered to be variable for that tree, while on a tree of the Corrugated strain all fruits other than those of the Corrugated strain are counted as variable. With the trees of the Sporting strain, however, the fruit of the Valencia strain is considered to be normal, and all variable fruits are counted as off type for those trees. The

relatively large number of variable fruits recorded on a few of the Productive trees of the Valencia strain, such as those listed in ranks 1, 2, 6, 7, 10, etc., are almost entirely composed of those described briefly under the heading "Minor variations of fruits." Occasionally on one of these trees a small branch has been found bearing a few fruits of one of the major strains, but usually the variable fruits found on Productive trees of the Valencia strain are not of a character to lessen the commercial value of the crop.

The working out of methods of interpreting these individual-tree performance records and of applying the knowledge gained from their study is essential. It is a simple matter to choose between healthy trees of the same age grown under identical cultural conditions when they have such widely different records as those presented for the trees listed in ranks 2 and 88 in Table I. But to make a choice between similarly grown trees with such performance records as those listed in ranks 2 and 3 is quite a different problem. The average annual production of these two trees for the four years was practically identical, 178.2 pounds and 178 pounds, but the actual yields each year varied considerably. The tree listed in rank 2 bore a gradually increasing amount of fruit during the 4-year period, while the one recorded in rank 3 bore heavily the first year, produced a lighter crop the next season, and an increasingly heavy one each succeeding year. The large number of variable fruits occurring on the tree in rank 2 is partly explained by the presence in the tree of a limb which produces fruits of the Ribbed strain. Both these trees appear to be of relatively high commercial value as crop producers and as sources of desirable bud wood for use in nursery propagation or for top-working trees of undesirable strains, and before any intelligent choice could be made between the two it would be necessary to know their performance records for one or two years more.

The annual-production records by fruit sizes for these two trees for the year 1912 when compared with the records for the succeeding years show a great variation in the proportion of fruit of the various commercial sizes in the crops of the individual trees. This variation was not due to the quantity of fruit on the individual trees, for it is equally marked on both these trees, although there is a considerable difference in the weight and number of fruit borne by them that season. The general production of oranges of large sizes during some years is well recognized by citrus growers and is thought to be the result of seasonal climatic conditions. An inspection of the annual performance records of the other trees presented herewith lends weight to this theory, for it will be found that, without exception, all the trees produced a relatively small number of small-sized fruit during the season of 1912 in comparison with the season of 1913, irrespective of whether or not the total yield during that season was larger or smaller

than in 1913. The 1915 records of many of the trees show this same tendency in a lesser degree, indicated by a relative decrease in production of fruits of the very smallest sizes, even where, as was the case with the tree listed in rank 3, the total crop for that year was larger than during the previous year.

Table II shows the percentage of fruit of the first or Orchard grade produced by each tree and the proportion of variable fruits recorded from each during the 4-year period. These percentages are calculated from the records of actual yields shown in Table I, and they are an aid in interpreting those data and in judging the relative commercial value of the individual trees both from the standpoint of crop production and as sources of desirable bud wood.

TABLE II.—*Performance records of 105 Valencia orange trees, showing the percentages of fruits of Orchard grade and of variable fruits borne by each tree, 1912 to 1915, inclusive.*

Rank in Table I.	Percentage of fruits.		Rank in Table I.	Percentage of fruits.		Rank in Table I.	Percentage of fruits.	
	Orchard grade (by weight).	Variable (by number).		Orchard grade (by weight).	Variable (by number).		Orchard grade (by weight).	Variable (by number).
1	78.6	3.5	36	62.0	2.9	71	70.6	0.6
2	67.7	7.3	37	59.0	2.1	72	72.1	2.7
3	67.9	.5	38	72.0	.7	73	77.6	.2
4	68.9	.5	39	81.3	.5	74	62.0	6.1
5	74.4	1.3	40	29.2	42.8	75	78.8	3.8
6	68.4	9.2	41	17.3	25.0	76	23.9	38.0
7	77.8	5.3	42	62.8	12.1	77	18.8	38.1
8	76.8	.6	43	72.7	.3	78	14.8	26.4
9	80.2	.4	44	46.1	26.1	79	24.4	37.9
10	73.4	5.7	45	50.7	13.5	80	52.5	7.5
11	71.9	4.8	46	67.2	2.6	81	73.7	2.5
12	64.3	6.3	47	22.9	33.5	82	79.8	3.9
13	77.6	.8	48	68.1	4.4	83	71.2	1.3
14	75.6	.9	49	60.5	4.8	84	68.1	6.5
15	75.2	.6	50	73.8	.8	85	72.4	1.1
16	69.5	.9	51	79.2	1.1	86	65.6	7.3
17	73.2	1.7	52	62.0	6.2	87	76.2	1.0
18	72.3	1.6	53	65.3	4.4	88	71.4	4.1
19	76.5	1.5	54	72.1	1.6	89	37.2	5.8
20	73.5	1.7	55	71.4	5.1	90	52.2	4.9
21	68.3	5.8	56	81.3	2.3	91	64.9	6.3
22	59.3	6.5	57	67.7	2.4	92	67.4	2.4
23	72.8	.7	58	71.9	5.2	93	12.2	18.5
24	70.8	4.0	59	73.4	5.3	94	64.5	5.6
25	70.8	7.3	60	57.7	7.2	95	55.1	7.8
26	65.5	4.2	61	59.3	4.2	96	45.6	13.0
27	63.3	9.1	62	65.8	.6	97	59.8	6.3
28	72.6	8.1	63	70.2	3.6	98	50.6	30.8
29	63.8	5.0	64	72.3	.5	99	57.4	13.1
30	61.0	6.4	65	67.2	7.9	100	60.6	5.2
31	73.3	.8	66	76.5	2.4	101	57.6	6.7
32	75.3	1.0	67	39.5	67.8	102	62.0	8.1
33	77.5	2.0	68	82.6	.3	103	72.0	12.1
34	70.2	4.5	69	67.7	7.2	104	19.3	40.9
35	79.8	1.2	70	77.4	6.6	105	.3	68.8

Table III shows in its first section (sec. A) the performance record of an orange tree of the Valencia strain for the season of 1915, as entered on the annual record form, and also the 4-year period performance record of the same tree. The detailed annual record is copied from the field notebook and shows the data therein recorded for each individual tree. The summary of this annual record is copied on the period form, as shown by the second

part of section A of the table. In order to economize space in publication, the detailed record form as shown here has been rearranged from that actually used in the investigations, but the summary records presented are in substantially the same form in which they were recorded. By means of this summary record form it is possible not only to compare the total crops for successive seasons, but also to study the relative amount of fruit in the different grades and sizes.

Sections B and C of Table III, showing both annual and 4-year period performance records for individual trees of the Corrugated and Barren strains, are given for comparison with section A of the same table. Considered as a series, these tabular statements show some of the great variations between trees of different strains, especially with respect to the amount of their total crops and the quality of the crops as indicated by the relative proportions of fruit of the different grades. These variations illustrate the relative value of these strains and are typical of the differences in production that exist in other strains of this variety. Considered as a record of individual trees, this table shows in detail the character of successive crops and their variations in quality and quantity.

TABLE III.—*Performance record of individual Valencia orange trees of different strains, showing the weight and number of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1915, and also summarized for four seasons, 1912 to 1915, inclusive.*

[This summarized record illustrates the method of assembling the data of successive seasons for careful comparison and study. In practice, the variable fruits produced by the tree each season and the record of the number of seeds found in representative fruits are listed on the back of the forms. The weights are given in pounds and ounces, except that the fractional averages are expressed decimally in pounds.]

SECTION A.—TREE No. 23-85-10, VALENCIA STRAIN, LISTED IN RANK 32 IN TABLES I AND II.

DETAILED RECORD FOR THE SEASON OF 1915.[1]

Sizes of fruits.	Orchard grade.		Standard grade.		Total.		Cull fruits.		Grand total.	
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.
	Lbs. oz.		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*	
288 and smaller	1 10	6	10 10	41	12 4	47	.....	.....	.....	.....
250	5 14	20	24 0	75	29 14	95	.....	.....	.....	.....
216	18 12	57	13 2	37	31 14	94	.....	.....	.....	.....
200	58 5	155	13 1	33	71 6	188	.....	.....	.....	.....
176	25 1	59	2 10	6	27 11	65	.....	.....	.....	.....
150	9 9	21	1 8	3	11 1	24	.....	.....	.....	.....
126	0 8	1	0 0	0	0 8	1	.....	.....	.....	.....
112	0 0	0	0 0	0	0 0	0	.....	.....	.....	.....
96	0 0	0	0 0	0	0 0	0	.....	.....	.....	.....
80 and larger	0 0	0	0 0	0	0 0	0	.....	.....	.....	.....
Total	119 11	319	64 15	195	184 10	514	0 12	4	185 6	518
Seeds found:										
Small fruits	.....	1	.....	3	.....	4	.....	3	.....	7
Medium fruits	.....	4	.....	7	.....	11	.....	1	.....	12
Large fruits	.....	5	.....	7	.....	12	.....	1	.....	13

[1] NOTES.—Total crop, 4½ boxes. Variable fruits: Australian, 1; Ridged, 2; Creased, 1; Raised section, 3; Abnormal section, 1; Split side, 1; Off bloom, 2.

TABLE III.—*Performance record of individual Valencia orange trees of different strains, showing the weight and number of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1915, and also summarized for four seasons, 1912 to 1915, inclusive*—Continued.

SECTION A.—TREE No. 23-85-10, VALENCIA STRAIN, LISTED IN RANK 32 IN TABLES I AND II—Continued.

SUMMARIZED RECORD FOR FOUR SEASONS.

Grades and sizes.	1912	1913	1914	1915	Total.	Average.
Weight of fruits:	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	
Orchard grade	91 5	96 9	111 4	119 11	418 13	104.7
Standard grade	19 1	19 1	16 11	64 15	119 12	29.9
Culls	7 0	7 9	2 8	0 12	17 13	4.5
Grand total	117 6	123 3	130 7	185 6	556 6	139.1
Sizes—						
288 and smaller	5 4	36 1	36 1	12 4	89 10	22.4
250	8 3	22 1	44 10	29 14	104 12	26.2
216	8 3	14 12	26 15	31 14	81 12	20.4
200	30 9	21 9	17 5	71 6	140 13	35.2
176	20 14	9 5	3 0	27 11	60 14	15.2
150	25 14	7 11	0 0	11 1	44 10	11.1
126	4 7	2 15	0 0	0 8	7 14	2.0
112	4 4	1 4	0 0	0 0	5 8	1.4
96	2 0	0 0	0 0	0 0	2 0	.5
80 and larger	0 12	0 0	0 0	0 0	0 12	.2
Total	110 6	115 10	127 15	184 10	538 9	134.6
Number of fruits:						
Orchard grade	204	295	302	319	1,120	280.0
Standard grade	46	77	53	195	371	92.8
Culls	17	78	13	4	112	28.0
Grand total	267	450	368	518	1,603	400.8
Sizes—						
288 and smaller	17	161	119	47	344	86.0
250	24	73	124	95	316	79.0
216	22	42	67	94	225	56.25
200	73	54	39	188	354	88.5
176	45	20	6	65	136	34.0
150	50	15	0	24	89	22.25
126	8	5	0	1	14	3.5
112	7	2	0	0	9	2.25
96	3	0	0	0	3	.75
80 and larger	1	0	0	0	1	.25
Total	250	372	355	514	1,491	372.75

SECTION B.—TREE No. 23-85-7, CORRUGATED STRAIN, LISTED IN RANK 47 IN TABLES I AND II.

[In 1912 and 1913 the fruits of this tree were not assorted according to size.]

DETAILED RECORD FOR THE SEASON OF 1915.[1]

Sizes of fruits.	Orchard grade.		Standard grade.		Total.		Cull fruits.		Grand total.	
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.
	Lbs. oz.		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*	
288 and smaller	0 0	0	4 1	15	4 1	15				
250	2 0	7	8 10	26	10 10	33				
216	2 4	7	10 12	29	13 0	36				
200	15 3	39	14 6	36	29 9	75				
176	8 13	20	18 2	40	26 15	60				
150	8 14	18	4 15	10	13 13	28				
126	6 6	12	2 5	4	8 11	16				
112	0 0	0	0 11	1	0 11	1				
96	0 0	0	0 0	0	0 0	0				
80 and larger	0 0	0	0 0	0	0 0	0				
Total	43 8	103	63 14	161	107 6	264	0 10	3	108 0	267
Seeds found:										
Small fruits		7		2		9		0		9
Medium fruits		4		2		6		1		7
Large fruits		8		4		12		2		14

[1] NOTES.—Total crop, 2⅛ boxes. Corrugated fruits tend to be long and pear shaped, greenish yellow in color. Sports: Wrinkled, 1; Corrugated, 132; Ridged, 7; Creased, 4; Sunken section, 1; Yellow section, 1; Long, 2; Green section, 1; Ridged and Creased, 3; Granular, 11; Half Corrugated, Half Standard, 1.

TABLE III.—*Performance record of individual Valencia orange trees of different strains, showing the weight and number of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1915, and also summarized for four seasons, 1912 to 1915, inclusive*—Continued.

SECTION B.—TREE No. 23-85-7, CORRUGATED STRAIN, LISTED IN RANK 47 IN TABLES I AND II—Continued.

SUMMARIZED RECORD FOR FOUR SEASONS.

Grades and sizes.	1912	1913	1914	1915	Total.	Average.
Weight of fruits:	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	
Orchard grade	18 1	31 1	20 14	43 8	113 8	28.4
Standard grade	119 9	76 2	114 4	63 14	373 13	93.5
Culls	2 13	3 4	2 7	0 10	9 2	2.3
Grand total	140 7	110 7	137 9	108 0	496 7	124.1
Sizes—						
288 and smaller			56 11	4 1		
250			40 11	10 10		
216			15 4	13 0		
200			16 9	29 9		
176			3 11	26 15		
150			2 4	13 13		
126			0 0	8 11		
112			0 0	0 11		
96			0 0	0 0		
80 and larger			0 0	0 0		
Total	137 10	107 3	135 2	107 6	477 5	121.8
Number of fruits:						
Orchard grade	39	89	61	103	292	73.0
Standard grade	266	216	339	161	982	245.5
Culls	9	36	12	3	60	15.0
Grand total	314	341	412	267	1,334	333.5
Sizes—						
288 and smaller			198	15		
250			115	33		
216			38	36		
200			38	75		
176			7	60		
150			4	28		
126			0	16		
112			0	1		
96			0	0		
80 and larger			0	0		
Total	305	305	400	264	1,274	318.5

SECTION C.—TREE No. 37-58-23, BARREN STRAIN, LISTED IN RANK 105 IN TABLES I AND II.

DETAILED RECORD FOR THE SEASON OF 1915.[1]

Sizes of fruits.	Orchard grade.		Standard grade.		Total.		Cull fruits.		Grand total.	
	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.
	Lbs. oz.		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*	
288 and smaller	0 0	0	1 0	4	1 0	4				
250	0 0	0	0 0	0	0 0	0				
216	0 0	0	0 0	0	0 0	0				
200	0 0	0	0 6	1	0 6	1				
176	0 0	0	0 0	0	0 0	0				
150	0 0	0	0 8	1	0 8	1				
126	0 0	0	0 0	0	0 0	0				
112	0 0	0	0 0	0	0 0	0				
96	0 0	0	0 0	0	0 0	0				
80 and larger	0 0	0	0 0	0	0 0	0				
Total			1 14	6	1 14	6	0 15	4	2 13	10
Seeds found:										
Small fruits		[2]		2		2		1		3
Medium fruits		[2]		2		2		2		4
Large fruits		[2]		5		5		3		8

[1] No sports.

[2] Seeds in fruits of the Orchard grade were not counted.

TABLE III.—*Performance record of individual Valencia orange trees of different strains, showing the weight and number of the fruits of each grade and size and the variable fruits produced, detailed for the season of 1915 and also summarized for four seasons, 1912 to 1915, inclusive*—Continued.

SECTION C.—TREE NO. 37-58-26, BARREN STRAIN, LISTED IN RANK 105 IN TABLES I AND II—Continued.

SUMMARIZED RECORD FOR FOUR SEASONS.

Grades and sizes.	1912	1913	1914	1915	Total.	Average.
Weight of fruits:	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	
Orchard grade	0 0	0 8	0 0	0 0	0 8	0.13
Standard grade	2 1	1 7	0 0	1 14	5 6	1.34
Culls	7 13	0 2	0 0	0 15	8 14	2.22
Grand total	9 14	2 1	0 0	2 13	14 12	3.69
Sizes—						
288 and smaller	0 9	1 7	0 0	1 0	3 0	.75
250	0 0	0 0	0 0	0 0	0 0	
216	1 2	0 0	0 0	0 0	1 2	.28
200	0 0	0 8	0 0	0 6	0 14	.22
176	0 6	0 0	0 0	0 0	0 6	.09
150	0 0	0 0	0 0	0 8	0 8	.13
126	0 0	0 0	0 0	0 0	0 0	0
112	0 0	0 0	0 0	0 0	0 0	0
96	0 0	0 0	0 0	0 0	0 0	0
80 and larger	0 0	0 0	0 0	0 0	0 0	0
Total	2 1	1 15	0 0	1 14	5 14	1.47
Number of fruits:						
Orchard grade	0	1	0	0	1	.3
Standard grade	6	6	0	6	18	4.5
Culls	40	2	0	4	46	11.5
Grand total	46	9	0	10	65	16.3
Sizes—						
288 and smaller	2	6	0	4	12	3
250	0	0	0	0		
216	3	0	0	0	3	.75
200	0	1	0	1	2	.5
176	1	0	0	0	1	.25
150	0	0	0	1	1	.25
126	0	0	0	0	0	0
112	0	0	0	0	0	0
96	0	0	0	0	0	0
80 and larger	0	0	0	0	0	0
Total	6	7	0	6	19	4.75

A comparison of the records of the trees listed in ranks 45, 51, and 54 of Tables I and II will bring out further the variations in production that may occur within a strain as that term is here employed. These three trees produced practically the same average yields for the 4-year period, but their crops for each year have varied considerably and in very different ratios.

The tree listed in rank 45 is representative of a small class which shows a gradual decrease in production each year. This is, of course, an undesirable condition, and in commercial practice such trees should be top-worked as soon as their production falls below the point of profitableness. The tree listed in rank 51 is representative of the most desirable group of any commercially valuable strain, namely, that one in which the crop production is gradually increased from year to year. The trees recorded in ranks 2, 5, 9, 16, 17, 21, 27, and 37

are also typical of this group, and many others in the list are classified with these, though they are not as representative as those mentioned. The tree listed in rank 54 is typical of the group commonly called alternate bearers or biennial bearers; that is, a season of normal or high

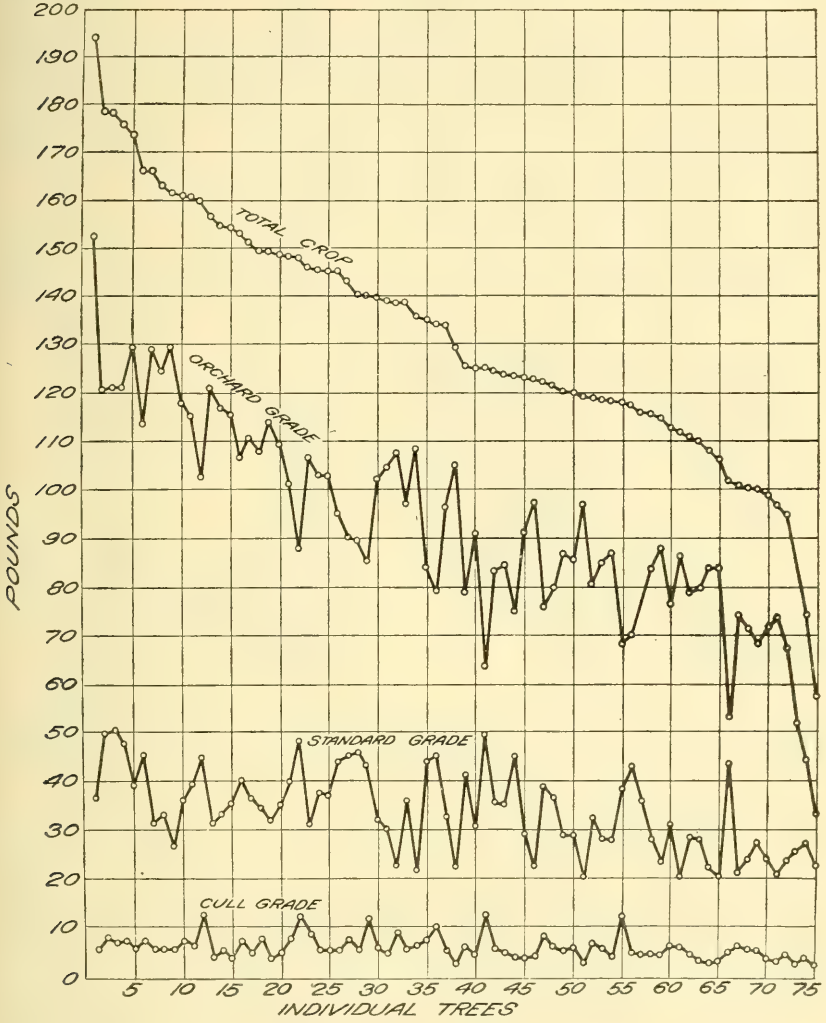

FIG. 1.—Diagram showing the average annual production of the 75 individual trees of the Valencia strain in the investigational performance-record plat for the 4-year period, 1912 to 1915, inclusive. The trees are here ranked in the order of their average total crop, expressed in pounds. The weight of the fruit of the three commercial grades is also shown for each tree.

production is followed by a small crop the next year, with the return of a normal crop the succeeding season. Usually these trees show a general increase in production during a period of years. This tree (rank 54) produced its small crops in the even years. The tree listed in rank 35 is also of this alternate-bearing character but bears its small

crops in the odd years. This group of trees may not be unprofitable to the grower, but they are not as desirable as those with a regular bearing habit.

The variation in the crop production of the individual trees of the Valencia strain in the performance-record plat is shown graphically in figure 1. The average annual crops of these 75 trees, which are planted in a single orchard block, vary from 57½ pounds to 193¾ pounds, but 64 of them, or 85 per cent of the total number, averaged between 100 and 160 pounds annually. This diagram also shows the variations in the amount of Orchard, Standard, and Cull grade fruit borne by trees producing practically the same total crops.

Section A of Table IV shows the average annual crop of all the Valencia orange trees occurring in the investigational performance-record plat in groups of strains and of select trees within some of these

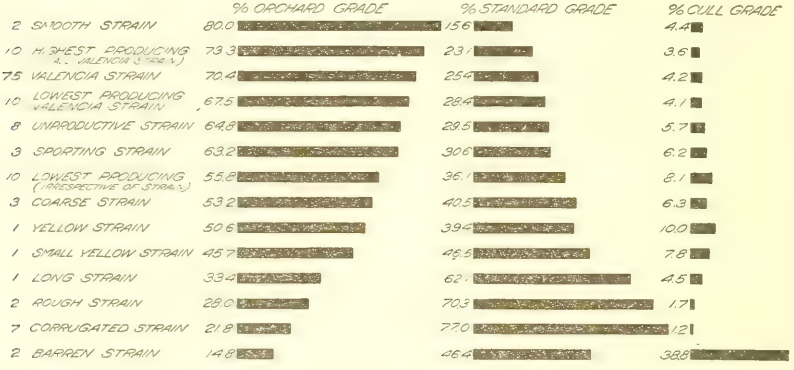

FIG. 2.—Diagram showing the percentages of fruit of the different commercial grades in the average annual production of the trees of the various strains found in the investigational performance-record plat of Valencia oranges for the 4-year period, 1912 to 1915, inclusive. The strains are listed in the order of their relative production by weight of fruit of the Orchard grade.

strains. The groups are arranged according to the weight of the average annual crop of each individual tree. The presence of Barren-strain trees will probably be a surprise to many Valencia growers. Trees of this strain and other low-producing strains when noticed in the orchards have usually been considered to be biennial bearers, in their off year. Records, such as those here reported, show that in some instances, at least, this theory is baseless. Here are shown the records of two trees of the Barren strain which have borne practically uniform crops for the past four years, with an average yearly crop of 6 pounds per tree, only 3.7 pounds being commercial fruit suitable for the market. It will be seen that nearly all the other sporting strains produced much less than is ordinarily expected from the average orchard tree and all of them averaged less than was produced by the trees of the Valencia strain.

Section B of Table IV shows the groups of trees of the different strains ranked according to the average annual crop of first, or Orchard, grade fruit produced. This change alters the relative position of several of the strains, but the Valencia strain is still at the head and the Barren strain at the foot of the list.

TABLE IV.—*Average annual crop of groups of trees of the variable strains of the Valencia orange occurring in the investigational performance-record plat, showing production by commercial grades for the 4-year period, 1912 to 1915, inclusive.*

Trees.		Average annual production per tree (pounds).			
Description.	Number.	Orchard grade.	Standard grade.	Cull fruits.	Total crop.
Section A.—Ranked according to their average total crops:					
Highest producing Valencia strain	10	125.9	39.6	6.1	171.6
Valencia strain	75	92.8	33.6	5.5	131.8
Sporting strain	3	80.7	39.0	7.9	127.6
Corrugated strain	7	24.7	87.4	1.4	113.5
Long strain	1	66.5	35.8	4.9	107.2
Coarse strain	3	53.1	40.4	6.2	99.7
Rough strain	2	27.6	69.2	1.7	98.5
Lowest producing Valencia strain	10	61.6	25.8	3.7	91.1
Small Yellow strain	1	36.1	36.8	6.2	79.1
Unproductive strain	8	50.0	22.8	4.4	77.2
Smooth strain	2	60.6	11.8	3.4	75.8
Yellow strain	1	36.5	28.4	7.2	72.1
Lowest producing trees	10	28.2	18.2	4.0	50.4
Barren strain	2	.9	2.8	2.3	6.0
General average		78.6	36.4	5.1	120
Section B.—Ranked according to the weight of fruit of Orchard grade produced:					
Highest producing Valencia strain	10	125.9	39.6	6.1	171.6
Valencia strain	75	92.8	33.6	5.5	131.8
Sporting strain	3	80.7	39.0	7.9	127.6
Long strain	1	66.5	35.8	4.9	107.2
Lowest producing Valencia strain	10	61.6	25.8	3.7	91.1
Smooth strain	2	60.6	11.8	3.4	75.8
Coarse strain	3	53.1	40.4	6.2	99.7
Unproductive strain	8	50.0	22.8	4.4	77.2
Yellow strain	1	36.5	28.4	7.2	72.1
Small Yellow strain	1	36.1	36.8	6.2	79.1
Lowest producing trees	10	28.2	18.2	4.0	50.4
Rough strain	2	27.6	69.2	1.7	98.5
Corrugated strain	7	24.7	87.4	1.4	113.5
Barren strain	2	.9	2.8	2.3	6.0
General average		78.6	36.4	5.1	120

It should be noted that the 10 highest producing trees of the Valencia strain are also the 10 highest producing trees in the plat, irrespective of strain. Table I shows that the highest producing tree of a strain other than the Valencia is twenty-eighth in rank.

Figure 2 shows graphically the percentages of Orchard, Standard, and Cull grade fruits in the average annual production of groups of trees of the various strains represented in the investigational performance-record plat. This diagram can best be interpreted by comparing it with Table IV, which shows the actual average crops of these groups of trees of the different strains. Although the trees of the Smooth strain head the list in figure 2, their actual average production was only 60.6 pounds of Orchard-grade fruit, with a total production of 75.8 pounds, so that in value to the grower they are

far below the trees of the Valencia strain. The trees of the Barren strain are again found at the foot of the list.

The percentages of the two grades making up the commercial crops in the various strains are shown graphically in figure 3. These data are based on the weight of the average production per tree for the 4-year period, and the strains are arranged in the order of the percentage of first, or Orchard, grade fruit produced. This diagram, like figure 2, can be interpreted rightly only by comparison with the data of actual yield as shown in Table IV.

Figure 4 shows the average weight of fruit of the different commercial sizes and grades which was produced during the 4-year period on the 10 highest producing trees in the investigational performance-record plat in comparison with the corresponding yields of the 10

FIG. 3.—Diagram showing the percentages of Orchard and Standard grade fruit per tree in the average annual commercial crops of the trees of the various strains found in the investigational performance-record plat of Valencia oranges for the 4-year period, 1912 to 1915, inclusive. The strains are listed according to their proportion by weight of Orchard (or first) grade fruit.

lowest producing trees of the plat. This diagram illustrates graphically the fact that the heaviest bearing trees produce a larger proportion of the most desirable and valuable sizes of fruits than the lowest producing trees. The most productive trees also bear the largest proportion of fruit of first, or Orchard, grade, so that they are more profitable from the standpoint of quality and size of fruits, in addition to being high producers. On the other hand, the lowest producing trees bear a much larger proportion of extremely small fruits and fruits of the Standard (or second) grade.

Figure 5 is similar to figure 4, in that it shows the percentages of fruit of the different commercial sizes which were produced by the 10 highest and the 10 lowest yielding trees in the performance-record plat, but in this diagram the figures are based on the number

of fruits produced instead of on the weight of the fruits. This serves to emphasize the small-sized fruits and the Cull grades.

Figure 6, like figures 4 and 5, shows the average number of fruits produced by the 10 highest and 10 lowest yielding trees, but the yields of fruit of the different sizes are expressed as percentages of a packed box. The highest producing trees bore an annual average of 2.15 packed boxes per tree, as compared with a yield of 0.63 of a packed box from the lowest yielding trees. This difference indicates something of the value and desirability of growing only trees of the best strain in commercial orchards. These yields are very low, especially those from the best trees, but it should be remembered in this con-

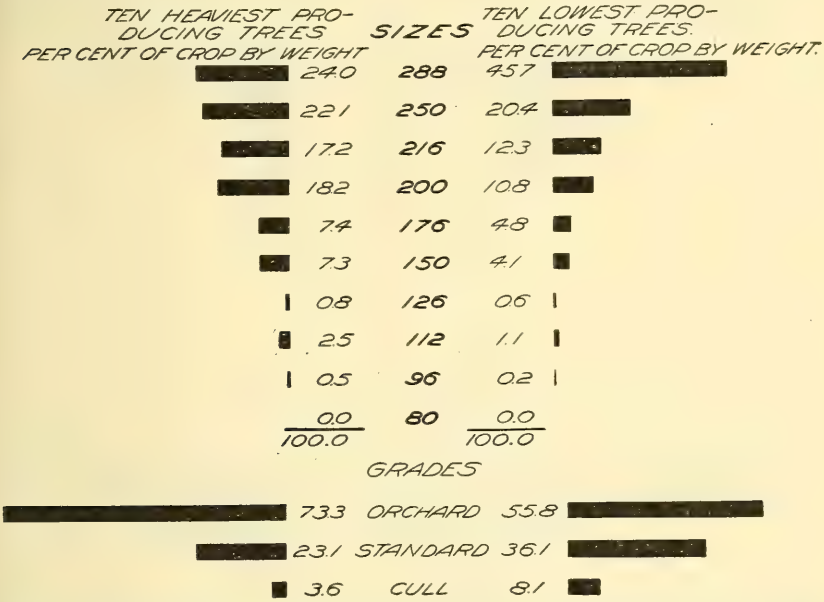

FIG. 4.—Diagram showing the variations in the commercial sizes and grades of fruit on the 10 heaviest producing trees in comparison with the 10 lowest producing trees in the experimental performance-record plat of Valencia oranges. The percentages are based on the weight of the average crop per tree for a 4-year period. Figure 5 shows similar variations based on the number of fruits produced.

nection that several of the conditions which were considered essential for the location of the performance-record plats were prohibitive to the production of large crops. It is also interesting and important, especially from the standpoint of dollars and cents, to note that the highest producing trees bore 33 per cent of their crop in the most desirable and valuable sizes, while the low-yielding trees had only 18.7 per cent of their crop in these sizes. Figuring the productions here shown on the acre basis at the rate of planting in the performance-record plat, it is found that the high producing trees bore 172 packed boxes as compared with 50.4 packed boxes per acre from the lowest producing trees. The values, delivered at the packing house, of

these calculated crops figured on the basis of the actual prices obtained during the investigational period, and considering the variations in grades and sizes produced per acre by the two groups of trees, would be $311.32 and $84.17, respectively.

This correlation of heavy yield and superior commercial grade in the production of trees of the Valencia strain is very important from the standpoint of the stabilization of the variety through bud selection based on performance records. Figures 4, 5, and 6 indicate that the propagation from the highest yielding trees means not only heavier production, but also improvement in the grade and size of fruit.

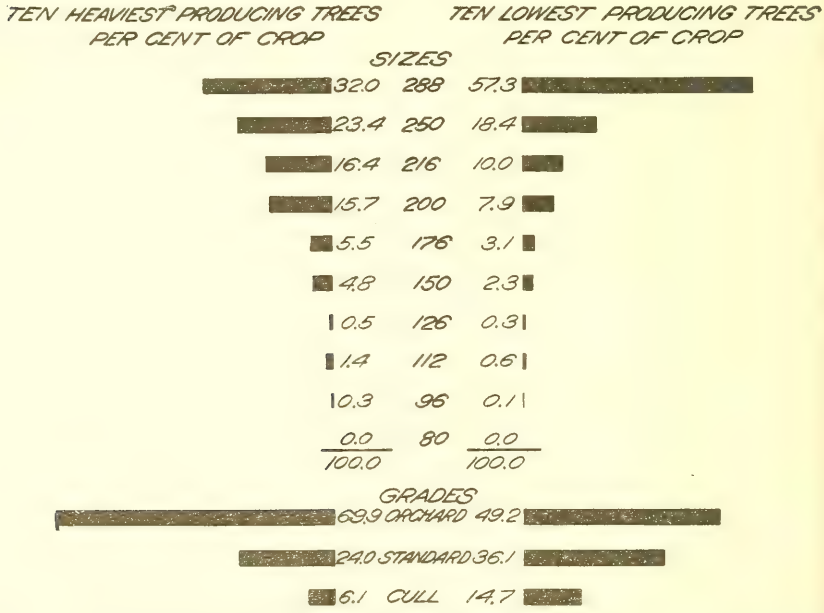

FIG. 5.—Diagram showing the variations in the commercial sizes and grades of fruit on the 10 heaviest producing trees in comparison with the 10 lowest producing ones in the investigational performance-record plat of Valencia oranges. The percentages are calculated from the number of fruits in the average crop per tree for a 4-year period. Figure 4 shows similar variations based on the weight of the crop.

Figure 7 shows graphically the relative number of variable fruits in the total crops of trees of the various strains of the Valencia orange occurring in the investigational performance-record plat. The diagram illustrates very well the comparative freedom from such fruits which characterizes the trees of the Valencia strain of this variety and the larger proportions of variable fruits which occur in the poorer and more undesirable strains. It is interesting to note that on the trees of the Barren strain, in addition to the almost entire lack of a crop of any sort, 84.3 per cent of what was produced was made up of sporting fruits. In counting the variable fruits on a tree only those showing some variation from the general type of the fruits

produced by that tree were recorded. For instance, in the case of the trees of the Valencia strain all other than Valencia fruits were considered as variable ones, while for the trees of the Corrugated strain all other than Corrugated fruits were recorded. For the trees of the Sporting strain all other than typical Valencia-strain fruits were counted as variable ones.

The comparative freedom of many trees of the Valencia strain from variable fruits indicates the possibility of controlling bud variability in propagation in commercial orchards by bud selection based on performance records.

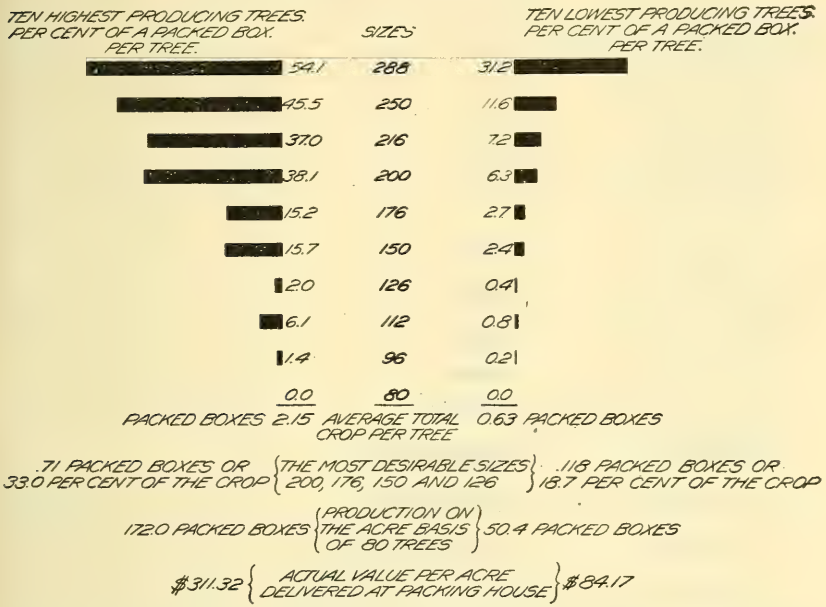

FIG. 6.—Diagram showing the average number of fruits of the various commercial sizes produced annually during the 4-year period, 1912 to 1915, inclusive, by the 10 highest yielding and the 10 lowest yielding trees in the investigational performance-record plat of Valencia oranges. This production is expressed as percentages of a packed box calculated from the average number of fruits of the different sizes. The percentage of most desirable sizes is also stated, and the production on the acre basis is shown and its value calculated from the actual returns during the four years.

The average number of seeds per fruit produced by trees of some of the various strains of the Valencia orange is shown in figure 8. This diagram, in comparison with Table IV, shows a very close correlation between the number of seeds per fruit and the comparative amount of Orchard-grade fruit produced by trees of the different strains here listed. It appears that the presence of three or four seeds per fruit is characteristic of the Valencia strain.

Many other interesting characteristics of the various strains of the Valencia orange have been studied during the progress of these investigations, but those presented here are among the most marked

and important. All the data show that it is very important to isolate the strains of this variety and, for commercial purposes, to propagate only the best of them.

COMPARATIVE VALUE OF THE STRAINS.

Any statement of the comparative value of the various strains of the Valencia orange must be understood as applying only to present conditions. What the future of some of these strains may be under different cultural and market conditions no one can now say.

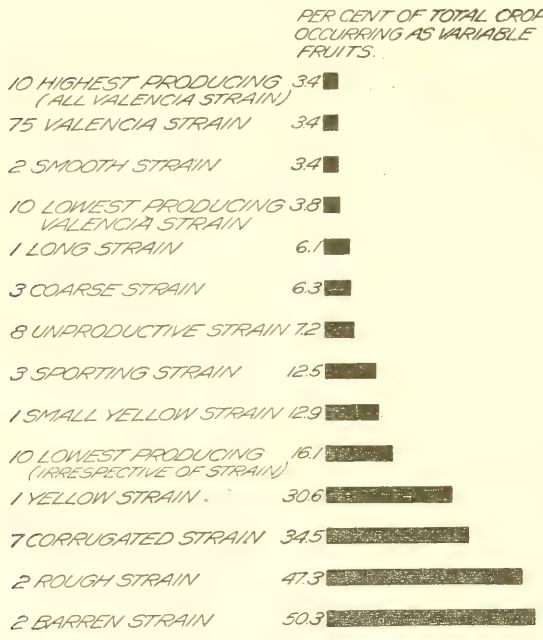

FIG. 7.—Diagram showing the relative number of variable fruits found in the average total crops of trees of different strains of the Valencia orange in the investigational performance-record plat during the 4-year period, 1912 to 1915, inclusive.

Under existing conditions, only one of the twelve strains here described is of commercial value, though three others are of possible value to orange growers. In some cases the inferior strains are not only unproductive, but the fruits produced by them are poor in quality or unattractive in appearance.

From a commercial standpoint the Valencia strain is the most valuable found so far in these investigations. Some others, especially the Smooth, Yellow, and Navel strains or selections from them, may prove desirable additions to the present varieties of summer-ripening oranges. After the value of any new strain has been determined, considerable time is required for its introduction and trial in sections having different climatic and soil conditions. This work of necessity is of a careful, experimental nature, requiring several years to obtain reliable results.

The remaining strains described in this bulletin are undesirable in nearly every respect, as will be readily apparent from the records and descriptions of them already presented. Since commercial orange growing is conducted for the profit to be obtained thereby, the further propagation of these inferior strains or their culture in

established plantings should be discouraged. For these reasons it seems wise for the present to concentrate effort upon the stabilization of the Valencia strain by means of bud selection based on performance records and intimate knowledge of the individual tree.

THE UNINTENTIONAL PROPAGATION OF UNDESIRABLE STRAINS.

The prevailing method of securing bud wood of the Valencia variety has been to cut it either from bearing trees in established orchards, or, to a limited extent, from young nursery or nonbearing trees. Where the buds have been cut from bearing trees little or, usually, no selection of parent trees has been practiced.

Bud variations have been propagated unintentionally by nurserymen because the existence and importance of such variations have been unknown until very recently. The occurrence of individual trees in the performance-record plats bearing mainly fruit identical with the fruit variations occurring individually or as limb sports in other trees and the existence of similar limb sports in the parent trees from which the performance-record trees were propagated are evidences of the propagation of these diverse strains from bud variations. From the fact that the most variable trees are usually the most vigorous in vegetative growth and that the most vigorous-growing, nonfruit-bearing wood has been usually selected for propagation, the proportion of trees of the variable strains in established orchards has been increasing continually in the later plantings as compared with the early propagations of this variety. Because of the lack of knowledge in the past of the existence of bud variations, no one can

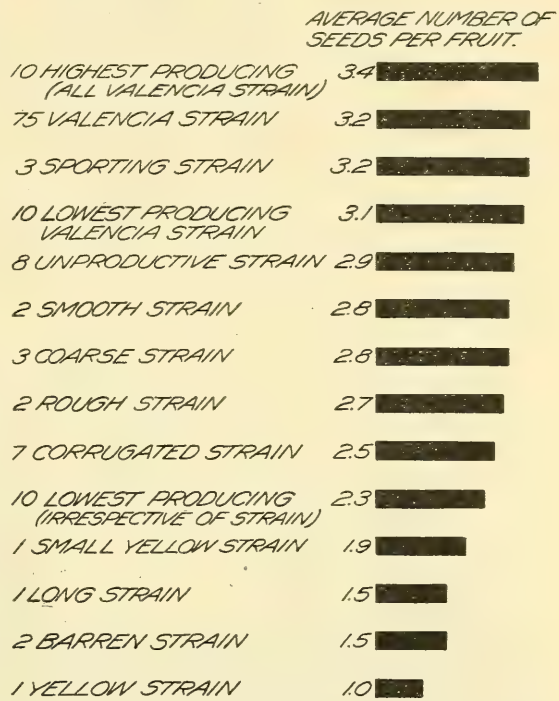

FIG. 8.—Diagram showing the average number of seeds found in fruits from the trees of the various strains of the Valencia orange in the investigational performance-record plat during the 4-year period, 1912 to 1915, inclusive. A large, a medium, and a small fruit from each of the three grades, that is, nine fruits from each tree, were cut each season and the seeds from each fruit carefully counted.

be blamed for the unfortunate and undesirable propagations of poor strains which have been so generally made. However, now that bud variability in trees of this variety has been established definitely, any propagator who does not carefully select his bud wood from trees of the best strain on the basis of their performance records will not be able to excuse the poor results of his propagations on the ground of the lack of information on this subject.

THE ISOLATION OF STRAINS THROUGH BUD SELECTION.

In the beginning of these investigations fruit-bearing bud wood was selected from limb variations in trees of the Valencia and other strains and top-worked in bearing trees in order to get them into fruiting quickly. About 100 such propagations have come into bearing, and as far as can be judged from trees of their age they have in every instance reproduced the strains which were propagated.

Later, as opportunity has permitted, the bud variations have been propagated on nursery stocks. These progeny tests will require several years to secure reliable performance-record data, but in so far as such trees have fruited the results have confirmed those secured by top-working bearing trees.

Enough evidence has been secured in these investigations to warrant the assertion that all of the 12 strains described in this bulletin can be isolated through bud selection. It seems probable that other strains also can be isolated in the same manner.

This conclusion does not include the idea that bud variation within these strains can be entirely eliminated. On the contrary, the investigations have shown that variation will likely continue as long as the strains are propagated. What has been demonstrated is that variation can be controlled by bud selection to such an extent that the individuals of a strain can be brought to a condition of practical uniformity as regards crop production and other characteristics.

Bud selection should be based on definite knowledge of the individual tree, which can be secured most satisfactorily by means of performance records and careful study. A thorough investigation of most of the established Valencia orchards in the light of individual-tree records will reveal the necessity for greater care in selecting buds for use in propagation.

The bud wood found most satisfactory in these investigations is that bearing typical fruits of the strain desired and of the one or two periods of growth preceding the production of the fruits. One or more fruits of the desired strain should be cut off with each bud stick as an indication or label showing the probable character of fruit that will be produced by the buds immediately back of the fruit. Figure 9 shows a bud stick cut in this manner with typical fruits of

the Valencia strain attached. When such bud wood is used, a larger number of desirable buds can be secured from heavy bearing

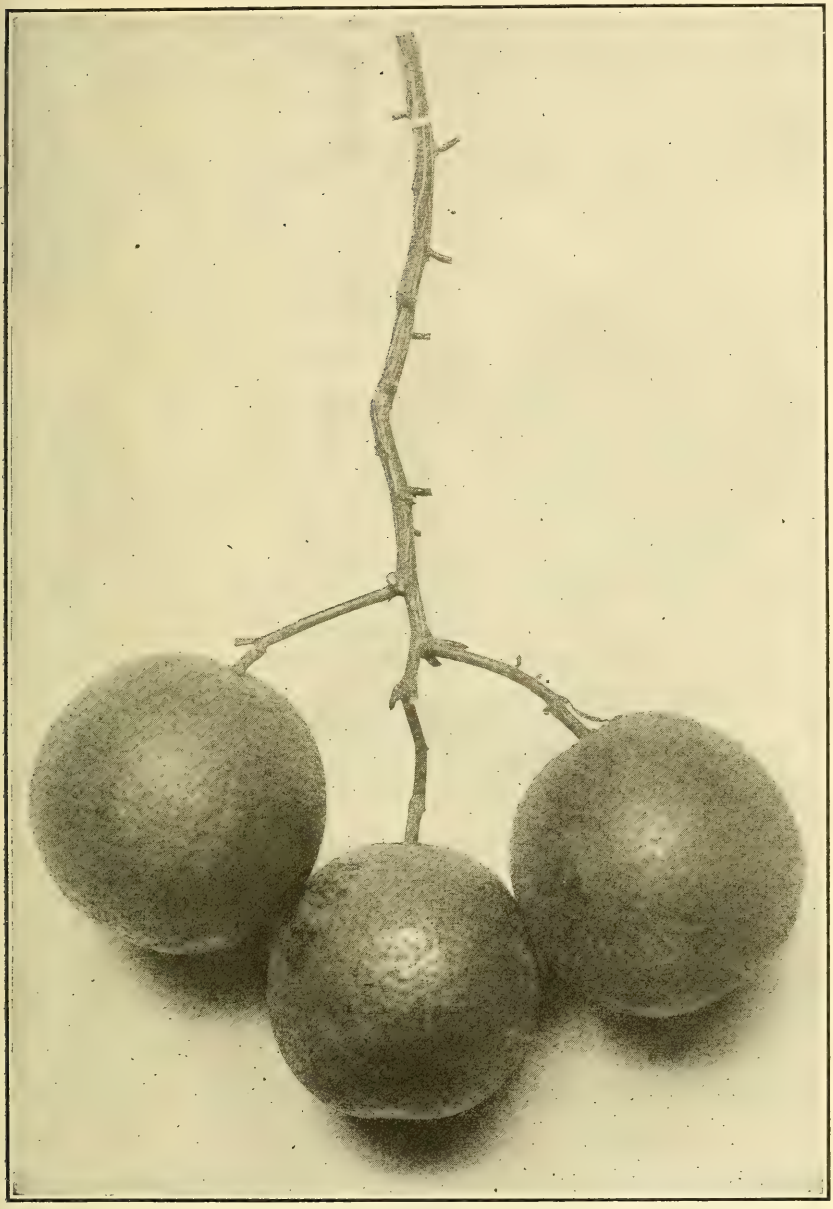

FIG. 9.—A Valencia orange bud stick of fruit-bearing wood cut with typical fruits of the Valencia strain attached. (About one-half natural size.)

trees than from less productive ones. When bud wood of this character was first recommended for use, nurserymen and propagators were almost unanimous in their objections to it on account of its

small size. Since that time this prejudice has gradually disappeared and thousands of buds from such wood have been used successfully in both experimental and commercial propagations.

If bud wood is desired at times when the fruits are unripe or when the bud wood is not in condition for use, it should be cut when the ripe fruits are available for inspection and stored in sterilized moss until needed.

The identification of a valuable strain is of vital commercial importance to the entire orange industry. The segregation of the inferior strains is of interest only from an experimental standpoint. The propagation of valuable strains will result not only in an increased production, but what is equally important, in a uniform production of crops of greater commercial value.

TOP-WORKING UNDESIRABLE TREES.

Healthy Valencia orange trees of inferior or undesirable strains can be successfully top-worked, using the kind of bud wood described in the preceding paragraphs. This bud wood can be used either as grafts or, as is the usual practice, for budding directly into some of the main limbs.

The selection of trees to be top-worked should be made before their fruits are picked. While trees of some inferior strains are easily recognized from their habits of growth or foliage characteristics, it is desirable wherever possible to base the selection of trees to be top-worked on their performance records and fruit characteristics. The selection of bud wood for top-working purposes should also be based on individual-tree performance records associated with an intimate knowledge of tree and fruit characteristics secured from careful observations in the orchards.

In top-working established trees, two or three of the main limbs should be selected for the foundation of the new heads. Two buds should be inserted in each of these limbs, from 12 to 24 inches above the fork of the trunk. After the buds have united with the older limbs, these limbs should be cut off about 6 inches above the point of insertion of the buds, and the cut surfaces covered with grafting wax or some pruning compound. The trunks and remaining portions of the limbs should be heavily whitewashed or otherwise protected, in order to prevent injuries from exposure. About a year later the stubs of the original limbs should be cut back close to the young buds, making the cuts oblique in order to facilitate their healing, and the cut surfaces should be again waxed or painted. In every case great care must be exercised in removing all sprouts from the trunk and old limbs in order to develop the new heads entirely from the inserted buds.

It is essential that the rebudded trees be inspected from time to time for the first year or two, in order that they may be cared for intelligently. The growth from the rebuds must be thinned occasionally, so that strong, open, and well-arranged tops will be secured. Insect enemies attacking the tender growth of the rebuds must be destroyed. Ten-year-old trees of inferior strains of the Valencia orange rebudded to the Valencia strain by the use of fruit-bearing bud wood usually will begin bearing in two or three years, reaching normal production in about four or five years.

As a result of these investigations, more than 5,000 undesirable Valencia orange trees in California orchards have been top-worked with buds selected from the most desirable trees in the investigational performance-record plats. The oldest tops grown from such buds are now more than four years old. So far not a single failure has been observed in transmitting the characteristics of the parent trees by means of the selected buds. Several thousand trees of undesirable strains of the Washington Navel orange and Marsh grapefruit also have been top-worked with selected buds of those varieties in the same manner during the past five years with equal success. This positive evidence as to the possibility of improving undesirable trees by top-working has resulted in the widespread adoption of this practice by California citrus growers.

SUMMARY.

In proportion to the area of the established Valencia orange orchards in California, the Valencia orange is being planted more extensively in that State than any other variety. It is now the leading summer-bearing orange variety grown in the State.

The object of these investigations is to discover methods of practice for the conservation and stabilization of the variety.

The plan of the investigation is a careful, detailed, and intimate study of the individual tree, the results of which are called individual-tree performance records.

The Valencia trees in these investigations were propagated from the variety originally introduced into California from Florida under the name of Hart (*Hart's Tardiff*).

In the performance-record plats considered in these investigations there are trees of 12 important strains and of many minor strains which have originated from bud mutations.

The frequent occurrence of bud variations in trees of this variety is of definite importance in the consideration of means for the improvement of the production of established orchards, the isolation of the best strains, and the control, as far as possible, of bud variation through bud selection based on performance records.

The most valuable strain of this variety is the Valencia. Some other strains may be of value under certain conditions.

Trees of the Valencia strain are most productive and bear the largest quantities of the best-grade fruit and the most valuable sizes for commercial purposes.

Trees of the Valencia strain produce fewer variable fruits than those of other strains.

All the strains described can be isolated through bud selection based on individual-tree performance records.

Healthy trees of undesirable strains in established orchards can be top-worked and their value improved thereby when fruit-bearing bud wood from selected trees of the Valencia strain is used for this purpose. A practical method for locating such trees and bud wood and a discussion of their treatment in commercial orchards are presented in Farmers' Bulletin 794 of the United States Department of Agriculture, "Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records."

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BULLETIN No. 625

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Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

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CROPPING SYSTEMS FOR THE MOISTER PORTION OF EASTERN WASHINGTON AND OREGON AND NORTHERN IDAHO.

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CLOVER IN THE ROTATION TO ELIMINATE SUMMER FALLOW.

WITHIN the region adjacent to the Bitter Root and Blue Mountains in Washington, Oregon, and Idaho live more than 12,800 farmers who operate approximately 1,875,000 acres of improved farm land. The farms on which these farmers live have an annual rainfall of 20 inches or more, and have a black silt loam soil underlaid by a clay-like subsoil which is very retentive of moisture. The land has been devoted to the growing of wheat, oats, and barley, by the summer-fallow system, for more than 30 years.

A farm survey made in 1915 on 246 farms in a representative portion of the above described area showed that 30.2 per cent of the rotation area was idle each season as summer fallow. It is generally conceded that the yields of grain are now smaller than when the land was first brought into cultivation and that the soil is growing more compact and harder to work with each succeeding year. It is generally believed that the practice of summer fallowing is largely responsible for this condition.

The amount of land idle as summer fallow and the per acre yield of crops were found to be the most potent factors influencing farm profits. Farms having the most summer fallow made the least profit, while those having the largest per acre yield of crops made the largest profits. Any cropping system, therefore, which will increase the per acre yield of crops or do away with summer fallow without decreasing yields should materially increase farm profits.

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On the silt loam soils of the Willamette Valley, Oregon, where climatic conditions are very similar to those of the Bitter Root and Blue Mountain regions, summer fallowing has been discontinued, without a decrease in yields. This result was accomplished through the use of legumes, principally clover, in the rotation. Recent studies show that the same result may be accomplished by the use of clover in that portion of eastern Washington, eastern Oregon, and northern Idaho having an annual precipitation in excess of 20 inches.

The fact that farmers in this section do not use more clover in the crop rotation is due, in large measure, to the prevailing idea that it can not be seeded in a nurse crop. In a study of this method of seeding clover the author found that in 100 trials, covering a period of 11 years, 1,507 acres of land in this region were seeded to clover with wheat, oats, or barley. A good stand of clover was secured on 1,408 acres, or 93.8 per cent of the total acreage seeded.

It was found that for successfully seeding clover with a nurse crop the following rules must be followed: (1) Use good seed; (2) the land must be free from weeds, especially wild oats; (3) the seed bed must be well prepared; (4) but about two-thirds as much grain (nurse crop) should be sown per acre as when no clover is sown; (5) seed early in the spring; and (6) inoculate the soil with nitrogen gathering bacteria, which will grow on the clover plant.

The per acre crop yields on farms where clover has been grown in the crop rotation is from 15 to 25 per cent larger than on farms where the summer-fallow method of growing wheat, oats, or barley is practiced. Three- and four-year rotations with clover are being carried on successfully in different sections of the above-described territory.

FACTORS INFLUENCING FARM PROFITS.

All farm-management studies show that there are certain factors within the control of the farmer which largely determine the profitableness of his business. As stated above, the most potent factors influencing profits on the farms studied in eastern Washington, eastern Oregon, and northern Idaho, as shown by the 1915 survey, were the amount of idle land in summer fallow and the per-acre yield of crops. The greater the percentage of rotation area in summer fallow, the smaller were the profits; the larger the crop yields per acre, the greater the profits. The effect of these factors on farm profits is shown in Tables I and II, which were taken from the 1915 survey of the above-described territory.

It will be seen from Table I that the group of farms having an average of 6.4 per cent of their rotation area devoted to summer fallow had an average of $490 labor income after deducting 8 per cent on capital invested.[1] On the other hand, the group of farms

[1] Eight per cent was the current rate on farm loans in this region in 1915.

which had an average of 46.5 per cent of their rotation area in summer fallow lacked $200 per farm of making 8 per cent on investment. Those farms with only 6.4 per cent of the rotation area in summer fallow made an average of 8.3 per cent interest on capital invested as compared with 5.9 per cent on farms having 46.5 per cent of the rotation area in summer fallow. It is evident from the crop yields of the different farm groups (see "Crop index," Table I) that the variation in profits in this case is not due to crop yield. The same 246 farms are grouped, however, on a basis of crop yields in Table II and the influence of this factor on farm profits brought out.

TABLE I.—*Percentage of rotation area in summer fallow in relation to profits on 246 farms in eastern Washington, eastern Oregon, and northern Idaho.*

Percentage of rotation area in summer fallow.	Average percentage rotation area in fallow.	Number of farms.	Labor income.[a]	Interest on investment.	Crop index.[b]
					Per cent.
Under 20 per cent	6.4	65	$490	8.3	98.2
20 to 30 per cent	25.6	62	302	7.5	101.0
30 to 40 per cent	34.8	70	— 20	6.3	102.4
Over 40 per cent	46.5	49	—200	5.9	96.8

[a] Labor income.—What the farmer has left after all expenses have been charged, including interest on the money he has tied up in his farm business.

[b] Crop index.—Crop yields as compared with the average of all farms, which is taken as 100 per cent.

TABLE II.—*Crop yields in relation to profits on 246 farms in eastern Washington, eastern Oregon, and northern Idaho.*

Farm group.	Number of farms.	Average crop index.	Labor income.	Percentage made on investment.	Percentage rotation area in summer fallow.
CROP INDEX.					
Under 90	65	79	—$220	5.5	28.7
90 to 99	62	94	105	6.6	29.6
100 to 110	54	104	297	7.5	32.1
Over 110	65	122	480	8.2	30.6

It will be observed from Table II that the farms with an average crop yield of but 79 per cent of the average of all farms lacked $220 of returning an interest of 8 per cent on the investment (minus $220 in "Labor income" column). As the per-acre yield of crops increases in the succeeding farm groups, the profits also increase until those farms having an average crop index of 122 made a labor income of $480 after deducting 8 per cent interest on capital invested. The interest made on capital for the farm group having the smallest crop index was 5.5 per cent compared with 8.2 per cent for the farm group having the highest yields per acre. The farms with an average crop index of 122 made a 27 per cent larger return on capital invested than did the farms with an average crop index of only 79. The table

also shows that in this case the variation in profits for the farm groups was not due to the difference in the percentage of rotation area in summer fallow.

It will be seen from the two foregoing tables that any cropping system which either will increase yields or reduce the amount of land devoted to summer fallow without decreasing the crop yields will materially increase farm profits on these farms. It will, therefore, be the purpose of the following pages to present methods of crop improvement through the use of proper cropping systems, and also to show how the percentage of rotation area in summer fallow may be reduced without materially affecting the yields.

METHODS OF INCREASING FARM PROFITS.

The effect on crop yields of eliminating summer fallow from the rotation was shown in a farm survey on the silt loam soil farms of the Willamette Valley, Oregon. For more than 40 years this section grew wheat and oats by the summer fallow system. The farm practice followed during this period was almost identical with that of eastern Washington, eastern Oregon, and northern Idaho at the present time. The crop yields gradually decreased from year to year until farming became so unprofitable that a change had to be made in the cropping systems. Legumes were introduced into the crop rotation and the amount of land devoted to summer fallow was decreased until in 1912 only 2.7 per cent of the rotation area was idle.

TABLE III.—*Relation of summer fallow to crop yields on 144 silt loam soil farms in the Willamette Valley, Oreg.*

Item.	Farms without summer fallow.	Farms with summer fallow.
Number of farms	127	17
Average yields per acre:		
Potatoes (bushels)	155.9	98.4
Wheat (bushels)	21.9	23.5
Oats (bushels)	37.9	36.5
Hay (tons)	1.94	1.76
Crop index	101	96

In Table III is given a comparison of per-acre yields between farms having summer fallow and those having none in the Willamette Valley. It will be seen that farmers on the silt loam soil in the Willamette Valley eliminated summer fallow from their rotation without reducing the average crop yield. Wheat was the only crop which produced more per acre on farms with summer fallow than on those without. These results were accomplished through the introduction of legumes, principally clover, into the rotation.

TABLE IV.—*Relation of field crop area in legumes to crop yields per acre on 144 silt loam soil farms in the Willamette Valley, Oreg.*

[Farms grouped according to percentage of field crop area in legumes. a]

Item.	None.	Under 18 per cent.	18 to 33 per cent.	Over 33 per cent.	All farms.
Average percentage crop area in legumes	None.	12.0	26.0	44.8	20.4
Number of farms	35	37	37	35	144
Average yields per acre:					
Potatoes (bushels)	132.8	145.5	172.0	183.5	150.2
Wheat (bushels)	18.8	21.5	23.8	23.7	22.0
Oats (bushels)	28.5	38.3	40.9	44.5	37.7
Hay (tons)	1.82	2.00	1.86	2.07	1.94
Crop index	82.8	100.4	105.0	111.4	100.0

a Clover occupied 58 per cent of the area in legumes.

TABLE V.—*Percentage of field crop area in clover in relation to farm profits and yields on 144 silt loam soil farms in the Willamette Valley, Oreg.*

[Farms grouped according to percentage of field crop area in clover.]

Item.	None.	Less than 20 per cent.	More than 20 per cent.	All farms.
Average percentage of field crop area in clover	None.	11.2	32.7	11.7
Number of farms	64	42	38	144
Average capital	$20,547	$22,920	$21,372	$21,457
Average farm income	$1,098	$1,546	$1,834	$1,425
Average labor income	−$135	$171	$560	$138
Average per cent made on investment a	5.34	6.75	8.63	6.64
Crop index	95.8	102.7	110.7	100.0

a Per cent made on investment in this table means per cent farm income is of capital.

The relation of field crop area in legumes to crop yields is shown in Table IV. The per acre yields of the four principal crops, potatoes, wheat, oats, and hay showed a marked increase on farms devoting more than 33 per cent of their rotation area to legumes over the per acre yield of those growing no legumes. The increases in yields in a comparison of the two groups of farms were as follows: Potatoes, 38.2 per cent; wheat, 26.1 per cent; oats, 56.2 per cent; hay, 13.7 per cent. The average increase in yields due to the use of legumes, for all crops, as shown by the crop index, was 34.5 per cent. The largest increase in crop yields occurred in comparing the group having an average of 12 per cent of the crop area devoted to these crops and the group of farms having no legumes. The increase in crop yields as between these two groups amounts to 21.3 per cent, while the increases as between the second and third and the third and fourth groups are 4.7 per cent and 6.1 per cent, respectively. (See Table V.)

The crop index indicates that those farms having more than 20 per cent of their field-crop area in clover had 15.5 per cent larger yields than farms without clover. The group of farms which grew no clover made a minus labor income of $135; that is, the net farm profits lacked $135 of amounting to 6 per cent of the capital invested.[1]

[1] Six per cent was the current rate on farm loans in this region in 1912.

The groups of farms which devoted less than 20 per cent of their field-crop area to clover made an average of $171 after deducting 6 per cent interest on capital invested, and the group which devoted more than 20 per cent of their field-crop area to clover made an average of $560 each. The increase in profits was due (1) to the increase in yields and (2) to the profitableness of clover-seed production in comparison with other farm crops for the year in which these records were taken (1912). It will also be seen from the interest made on investment that those farms devoting more than 20 per cent of their field crop area to clover used the capital invested in land and equipment 54.2 per cent more efficiently than the farms growing no clover.

The beneficial effect of clover in the rotation is quite generally recognized among the farmers of the moister sections of eastern Washington, eastern Oregon, and northern Idaho. The importance of this crop, however, as a means of maintaining a profitable system of farming and of improving the soil fertility is very much underestimated. The roots and stubble of a good clover crop are said to contain fertilizing elements equivalent per acre to from 3 to 5 tons of barnyard manure. Its value to the soil in supplying organic matter and thus improving the physical condition can not be estimated. A study of Tables III, IV, and V should convince the most skeptical farmers that clover is one of the biggest factors in building up a profitable farm business. The maintenance of soil fertility in the section above described is as much dependent on legumes, especially clover, as are the silt loam soil farms in the Willamette Valley, Oreg. A recent study by the author of a few farms in different parts of this region on which clover is being used in the rotation showed that they were returning from 15 to 25 per cent larger yields than farms not growing this crop.

SEEDING CLOVER WITH A NURSE CROP.

The small acreage devoted to clover in the moister section of eastern Washington, eastern Oregon, and northern Idaho is due in large measure to the prevailing idea that in order to secure a stand this crop must be seeded alone. The labor of preparing the soil and of seeding the crop by this method is practically the same as for small grain. The use of the land is also lost for one year except for the small amount of pasture that can sometimes be obtained. A few farmers in different localities, however, have broken away from this practice and are seeding clover with a grain crop. This method of seeding requires but little more labor than is necessary for seeding grain alone, and the nurse crop returns a profit while the clover is becoming established. The methods used by a number of farmers and their success in seeding clover with a nurse crop was studied during the past four years with the view of determining the feasibility of this method of seeding in this region.

TABLE VI.—*Results of seeding clover with a nurse crop in that portion of eastern Washington, eastern Oregon, and northern Idaho having an annual precipitation of 20 inches or more.*

Nurse crop.	Number of trials.	Acres tried.	Acres success.	Per cent success.
Winter wheat	17	141	107	75.9
Spring wheat	18	294	284	96.5
Oats	33	388	348	89.7
Barley	32	684	669	97.8
Total	100	1,507	1,408	93.4

It will be seen from Table VI that the number of trials and the total number of acres seeded to clover were sufficient for drawing definite conclusions. The trials covered a period of 11 years (from 1904 to 1916, inclusive, with no trials in 1905 or 1908), which is a sufficient length of time to eliminate the question of variation in climatic conditions from season to season. In the 100 trials reported there were 1,507 acres of clover seeded, with four different nurse crops. A good stand was obtained on 1,408 acres, or 93.4 per cent of the area seeded. Barley proved to be the best nurse crop, as a good stand of clover was secured on 97.8 per cent of the area seeded in barley as compared with 96.6 per cent of the area seeded in spring wheat, 89.7 per cent of the area seeded in oats, and 75.9 per cent of the area seeded in winter wheat. The high percentage of failure when clover was seeded in the spring with winter wheat is attributable to the fact that the wheat was too far advanced when the clover was sown. Very good results, however, have been obtained when the clover was sown in the very early spring before the wheat plants began growing.

When clover is to be seeded in the spring with winter wheat, from 8 to 10 pounds of seed per acre is sown and harrowed in before the grain starts growing. If the nurse crop is to be spring grain, the ground should be plowed in the fall or very early spring and worked into a mellow, shallow seed bed 2 or 3 inches in depth. It is very important that the subsurface below this depth be quite firm. From 8 to 10 pounds of clover seed per acre may be sown broadcast by hand or with a wheelbarrow grass seeder after the nurse crop has been seeded. The usual method, however, is to sow the grain and clover at one operation, using a grain drill having a grass-seed attachment. The clover seed should not be run into the grain tubes of the drill, as the seed are liable to be planted to such a depth that the plants will not reach the surface of the ground. The depth of planting should never be greater than 1½ inches. The drag harrow should be run immediately behind the drill. In case the ground is very loose a corrugated roller may be used to advantage in securing a stand of clover.

The field notes taken in connection with this investigation indicate that the factors contributing to the success or failure of clover seeded with a nurse crop are within the control of the farmer. Most of the failures were due to foul land or poor seed-bed preparation. Special care should be taken to have the land free from wild oats or other weeds. The nurse crop was often too thick. It dried out the soil and killed the clover plants before the grain was harvested or left them in such a weakened condition that they were killed by the dry weather which usually comes after harvest time. Poor seed, late seeding, and the lack of proper soil inoculation were elements which caused many failures. The best results are obtained from seeding clover on soil which is inoculated with the proper kind ofnitrogen-gathering bacteria and which is rich in organic matter.

The nitrogen-gathering bacteria are so essential to success that land which has never raised clover should be inoculated; that is, supplied with nitrogen-gathering bacteria which will produce nodules on the roots of the clover plant.

There are two ways of doing this, the pure culture and the field soil methods. Pure cultures may be secured in small quantities from the United States Department of Agriculture or may be purchased in large quantities from commercial dealers or in some States from the agricultural college. Directions for using the cultures go with them. The pure culture method of inoculation usually costs from $0.25 to $2 per acre, while the field-soil method costs practically nothing and entails extra work only in getting inoculated soil. The soil should be gathered from about clover plants which bear nodules on their roots. The soil can then be dried and pulverized in the shade. It may be stored away for months in a dark basement, and for spring seeding it is a good plan to keep a sufficient quantity in this manner to inoculate the amount of seed to be sown the following spring. The seed should be placed on a tight floor and thoroughly dampened with from 2 to 3 quarts of water per bushel. About 2 quarts of the pulverized soil is then sprinkled on the seed as it is shoveled over in order to get a coating of dust on each seed. It is then allowed to dry in the shade and kept from the sunlight until used. If the soil to be used in inoculating clover seed is sandy, the addition of one-fourth of a pound of glue per gallon of water will cause the dirt to stick to the seed better. When the soil is gathered in the spring and can not be dried for pulverizing it may be mixed with water at the rate of about 2 quarts of dirt to 3 gallons of water. The seed is then dampened at the rate of about 2 quarts of the mixture per bushel and allowed to dry in the shade before sowing.

ROTATION FOR INCREASING PROFITS.

The majority of farmers in those sections of eastern Washington, eastern Oregon, and northern Idaho having an annual precipitation in excess of 20 inches follow a three-year rotation of wheat, oats, or barley, and summer fallow. Many are to be found, however, who have broken away from this type of farming on at least part of the farm and are eliminating the summer fallow on small areas by the use of clover in the rotation. In Nez Perce, Lewis, and Idaho Counties, Idaho, clover is used to quite an extent. A study of the cropping systems of this region shows that clover may be used with as much success there as in the Willamette Valley, Oreg.

The usual method of establishing a crop rotation is to divide the farm into equal parts and change the crop on each field from year to year. For example, a three-year rotation of winter wheat, oats, and clover would be planned as follows:

TABLE VII.—*Usual form of three-field, three-year rotation of winter wheat, oats, and clover.*

Year.	Field A.	Field B.	Field C.
First year	Winter wheat	Oats	Clover.
Second year	Clover	Winter wheat	Oats.
Third year	Oats	Clover	Winter wheat.

On account of the hilly nature of the farm land in the section under discussion fields must be laid out in such a manner as to facilitate the operation of farm machinery. For this reason it is not always easy for the farmer to divide the farm so that an equal area may be devoted to each crop of the rotation. The rotation may be carried out, however, on each field during three successive seasons. The crops to be grown on each field should be so selected that approximately one-third of the farm area is devoted each year to one crop of the rotation.

THREE-YEAR CROPPING SYSTEMS.

The farmers of this section who do not wish to grow intertilled crops may introduce clover by using one of the following cropping systems:

First year.	*Second year.*	*Third year.*
Spring wheat, oats, barley, or field peas. (The grain is seeded as a nurse crop with clover.)	Clover for hay, seed, or pasture.	Spring wheat, oats, barley, or field peas.

Clover is seeded with spring wheat, oats, barley, or field peas during the first year. In the second year the clover which was seeded the

previous season is used for hay, seed, or pasture, on ground which will be planted to spring crops the following year. The third year of the rotation is devoted to the growing of winter wheat, spring wheat, oats, or barley. Winter wheat, as already stated, is usually seeded on land which grew clover until about May 1 and was then summer-fallowed, although spring crops may be used. Spring wheat, oats, barley, or field peas give best results on ground from which the clover was used for hay, seed, or pasture.

Farmers who wish to grow intertilled crops instead of summer fallowing their land may use one of the following systems:

First year.	*Second year.*	*Third year.*
Corn, beans, potatoes, or field peas planted in rows and intertilled.	Winter wheat, spring wheat, oats, barley, or field peas. (Grain is seeded as a nurse crop with clover.)	Clover for hay, seed, or pasture.

The first year of these cropping systems is devoted to the growing of corn, beans, potatoes, or field peas planted in rows and intertilled. In those sections where the climatic conditions are unfavorable for growing corn or beans the farmers must depend on potatoes or field peas for an intertilled crop. During the second year of this cropping system the ground from which the crop can be harvested in time for fall seeding may be used for winter wheat. The pea and bean crops may always be harvested in time to permit fall seeding, but unless the corn crop is cut for ensilage or for fodder and hauled from the field, spring grain must be sown. Winter grain is sometimes seeded, however, in the standing corn with a one-horse, five-hoe grain drill, and the corn crop husked from the standing stalk in the usual manner. As a rule, potatoes may be dug early enough to permit fall seeding unless they are very late in maturing. Spring wheat, oats, barley, or field peas all do exceptionally well on land which was devoted to intertilled crops the previous season. In using any of the above crops it must be remembered that they are to be sown as a nurse crop with clover. The third year of the rotation the clover is used for hay, seed, or pasture. It is very important that clover land be plowed in the fall when possible to do so.

FOUR-YEAR CROPPING SYSTEMS.

Many farmers in the above-described territory wish to summer fallow or grow a cultivated crop on the land once in four years. In

order to include clover in this sort of rotation one of the following four-year cropping systems may be used:

First year.	*Second year.*	*Third year.*	*Fourth year.*
Corn, beans, potatoes, or field peas planted in rows and cultivated in rows; summer fallow.	Winter wheat, spring wheat, oats, barley, or field peas.	Spring wheat, oats, barley, or field peas. (Grain seeded as a nurse crop with clover.)	Clover for hay, seed, or pasture.

For farmers who wish to use intertilled crops instead of summer fallowing, the first two years of this plan are the same as the first two years of the preceding three-year rotations. Farmers who do not wish to grow intertilled crops may substitute summer fallow during the first season. During the third year spring wheat, oats, barley, or field peas is seeded as a nurse crop with clover, and the fourth year the clover is used for seed, hay, or pasture.

CLOVER FOR SEED.

As clover is a comparatively new crop in the moister sections of eastern Washington, eastern Oregon, and northern Idaho, many farmers are not familiar with its use. On every farm it is possible to utilize a limited acreage of this crop for supplying the live stock with hay and pasture. The area so occupied, however, would be small in comparison with the total area under cultivation, as only a small number of animals are kept per farm. Thus it would not be possible to use clover often enough in the rotation materially to affect yields if this were the only way in which it could be used. By growing it for seed as well as for hay or pasture, however, the area devoted to this crop could be increased until from one-fourth to one-third of the tillable land would be devoted to clover every year. That clover seed may be successfully and profitably produced has been proved by several years' experience in parts of Idaho, Lewis, and Nez Perce Counties, Idaho. Seed production was started in eastern Nez Perce County in 1908 and the first clover seed huller was brought into the county a year later. The amount of land devoted to clover seed production gradually increased until in 1916 six clover hullers were necessary to care for the seed crops. The farmers who have grown seed find not only that it is a profitable crop but that the subsequent grain crops yield from 15 to 25 per cent per acre more than from land where clover was never produced.

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THE HANDLING AND PRECOOLING OF FLORIDA LETTUCE AND CELERY

By

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The investigations upon which this bulletin is based were made in the fruit and vegetable handling and storage division of the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry. The fruit and vegetable handling, transportation, and storage investigations of the Department of Agriculture are now prosecuted jointly and cooperatively by the Bureau of Plant Industry and the Bureau of Markets.

Actively associated in the prosecution of these investigations were H. C. Thompson, horticulturist; S. J. Dennis, technologist; G. W. Dewey, C. L. Dyer, J. F. Fernald, G. L. Fischer, W. E. Mosher, W. C. Quick, and E. D. Vosbury, of the Office of Horticultural and Pomological Investigations, and K. B. Lewis, formerly of that office.

This bulletin is of special interest to all growers and shippers of lettuce and celery in the Gulf States, particularly Florida, and of general interest to truck growers in other parts of the country. It also contains information of value to railroad and steamship lines handling these products, to cold-storage men, and to receivers of lettuce and celery from Florida and the Gulf States.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 604

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER March 16, 1918

INCENSE CEDAR

By

J. ALFRED MITCHELL, Forest Examiner

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 607

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER June 7, 1918

TESTS OF THE ABSORPTION AND PENETRATION OF COAL TAR AND CREOSOTE IN LONGLEAF PINE

By

CLYDE H. TEESDALE, in charge, Section of Wood Preservation, and
J. D. MacLEAN, Assistant Engineer in Forest Products
Forest Products Laboratory, Madison, Wis.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 608

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. ▼ March 6, 1918

VARIETIES OF CHEESE: DESCRIPTIONS AND ANALYSES

By

C. F. DOANE, Dairy Manufacturing Specialist, Dairy Division, and H. W. LAWSON, Formerly of the Office of Experiment Stations

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 614

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C. April 20, 1918

COST OF PRODUCING APPLES IN YAKIMA VALLEY, WASHINGTON

A DETAILED STUDY OF THE CURRENT COST FACTORS INVOLVED IN THE MAINTENANCE OF ORCHARDS AND THE HANDLING OF THE CROP ON 120 REPRESENTATIVE BEARING ORCHARDS

By

G. H. MILLER, Assistant Agriculturist, and
S. M. THOMSON, Scientific Assistant

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 616

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER February 14, 1918

THE CITRUS THRIPS

By

J. R. HORTON, Scientific Assistant

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 618

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER March 13, 1918

EXPERIMENTS WITH DURUM WHEAT

By

CARLETON R. BALL, Agronomist in Charge, and J. ALLEN CLARK
Scientific Assistant, Western Wheat Investigations
Office of Cereal Investigations

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 619

Contribution from the Bureau of Biological Survey
E. W. NELSON, Chief

Washington, D. C. PROFESSIONAL PAPER March 8, 1918

FOOD HABITS OF THE SWALLOWS

A FAMILY OF VALUABLE NATIVE BIRDS

By

F. E. L. BEAL, Assistant Biologist

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 620

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER March 14, 1918

EFFECT OF VARYING CERTAIN COOKING CONDITIONS IN THE PRODUCTION OF SULPHITE PULP FROM SPRUCE

By

S. E. LUNAK, Chemist in Forest Products

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 621

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E. W. NELSON, Chief

Washington, D. C. PROFESSIONAL PAPER. February 16, 1918

THE CROW AND ITS RELATION TO MAN

By

E. R. KALMBACH, Assistant Biologist

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 622

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER February 2, 1918

THE IDENTIFICATION OF VARIETIES OF BARLEY

By

HARRY V. HARLAN, Agronomist in Charge of Barley Investigations, Office of Cereal Investigations

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 623

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER July 22, 1918

CITRUS-FRUIT IMPROVEMENT
A STUDY OF BUD VARIATION IN THE WASHINGTON NAVEL ORANGE

By

A. D. SHAMEL, Physiologist in Charge, L. B. SCOTT, Pomologist, and C. S. POMEROY, Assistant Pomologist, Fruit-Improvement Investigations, Office of Horticultural and Pomological Investigations

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 624

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER July 25, 1918

CITRUS-FRUIT IMPROVEMENT A STUDY OF BUD VARIATION IN THE VALENCIA ORANGE

By

A. D. SHAMEL, Physiologist in Charge, L. B. SCOTT, Pomologist, and C. S. POMEROY, Assistant Pomologist, Fruit-Improvement Investigations
Office of Horticultural and Pomological Investigations

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